TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. VIII No. 4. APRIL, 1931. PRICE 6d.

CONTENTS.

	PAGE.
Fruit and Vegetables Trade	77
Witch broom Control	79
Citrus Propagation	90
Correspondence	93
The Mongoose	94
The Mongoose in Trinidad	95
Colonial Appointments	97
Biological Control	98
Cocoa in 1930	102
West Indian Notes	103
Sugar Notes	106
Chemical Notes	107
Trend of the Markets	108

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183.

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

FRUIT AND VEGETABLES TRADE.

The Development of the Trade between Canada and the British West Indies in Fruit and Vegetables.

THIS trade which is of comparatively recent origin has developed rapidly within the last two years. One of the factors contributing to its development has been the raising of the tariff on commodities by the United States since this has caused the West Indian Islands to seek for other markets for their produce and has directed the attention of Canada to the possibility of meeting some of its demands during the winter months for produce of this nature from adjacent parts of the British Empire. The advent of the Canadian National Steamships rather more than two years ago and the regular service of fine vessels, properly equipped for this class of trade that resulted, was another large contributing factor. The institution of this service has resulted in the visit of many Canadians to the Islands during the winter months and as a logical sequence, has directed the attention of prominent business men in the Dominion to the possibilities of extending trade.

The meeting of Agricultural officers at the West Indian Agricultural Conference which was held at the Imperial College of Tropical Agriculture in January, 1930, led to valuable discussions and did much to co-ordinate ideas and to crystallize plans for future development. The need for the closest co-operation between the various Islands that comprise the British West Indies in such matters as uniformity of packing, grading and variety was emphasised and the difficulties that confront the future development of this trade were in no way minimised, but definite plans were elaborated to deal with the situation in the future. As one result it may be mentioned that all the Islands of the Windward and Leeward Colonies have now established fruit packing sheds and peasant bureaux for the reception and handling of fruit and produce for export. This has entailed a great deal of hard work and organisation on the part of the administrative and agricultural officers and much has still to be done to equip the packing sheds properly for their work. Pre-cooling stations are, however, in process of erection in those Islands that are aiming at the export of the more perishable commodities such as tomatoes,

mangoes, and avocadoes, in order to enable them to carry over produce that arrives between the fortnightly sailings of the Canadian National ships. These refrigerating plants have been made possible at such places as St. Kitts, Montserrat and Dominica, by financial assistance from the Imperial Government. The further experience that has been gleaned this year now indicates that each of these packing sheds will probably have to be equipped with proper grading machines and the experience that has been gained by Bermuda in this connection should prove valuable. In Trinidad also the erection of a properly equipped packing shed for citrus which has now been decided upon will serve as a valuable guide to the smaller Islands.

The need for the closest possible co-operation between the various packing sheds is obvious, and the fruit conference that was held in St. Lucia last December, under the Chairmanship of Professor H. A. Ballou, Commissioner of the Advisory Department of this College, led to many useful results in this direction. This conference was attended by representatives of the Windward and Leeward Islands Colonies and arrived at definite conclusions on the following points which will now be adopted by all the Islands concerned as a general practice.

1. *Uniformity of Varieties.*—The names of definite varieties of fruit and vegetables are laid down as suitable for export to Canada.

2. *Uniformity of Packing.*—The dimensions and other particulars of standard containers for different produce are definitely laid down.

3. Definite instructions with regard to wrappers, labels, and the marking of fruit are enumerated.

The above are some of the valuable decisions arrived at by the conference but it is suggested that the list of varieties and possibly other points should be reviewed in the light of experience at regular intervals, at small conferences held on similar lines. As an example it may be found that the variety of tomato named may not prove to be the most suitable a year or two hence. Fashions change in the fruit trade as elsewhere, and there is always the factor of disease. From experiments that are now being conducted by the Mycological Department of the Imperial College it has already been demonstrated that certain well-known varieties differ in their susceptibility to certain diseases under West Indian conditions. As the results of these and similar investigations become available it will undoubtedly prove necessary to change the variety and revise the recommendations in other directions.

In order to ensure that the findings of this conference are carried out the appointment of a marketing officer, whose duty will be to train the local packers and to see that the standards laid down are strictly interpreted in all the Leeward and Windward Islands, becomes an absolute necessity. Packing and grading are technical operations and with all the goodwill in the world the local officers cannot meet the demand of the Canadian market at present because they have not the necessary expert knowledge. It is hoped therefore that the request for funds to meet the cost of a trained officer for this work will meet with a suitable response, as the future development of this trade depends largely on his immediate appointment.

Another matter that will shortly need attention, is the marketing of the crops in Canada. At present there is a danger of flooding the Canadian market at certain times of the year. For instance, the market for tomatoes is not so large as was at first anticipated. Probably 6,000 crates a week would be a fair average during the winter and spring months. Recently two large shipments from the Bahamas flooded the market and caused considerable trouble. A central marketing agency, if it could be established as recommended by the St. Lucia conference, would probably avoid trouble of this sort, and would result in a spread over of the crop. This would enable the damper islands such as St. Lucia and Dominica to supply the late spring demands in this vegetable after the crops on the islands less favoured by rainfall have finished.

The interest shown in Canada is very real and at the earnest invitation of their President, Mr. G. A. Jones, the Assistant Commissioner of the College Advisory Department, was sent to the Eastern Canada Fruit Jobbers and Brokers conference that was held in St. John's, New Brunswick, last January. He was able to establish contact with the various markets and was able to glean much valuable information which should be of great benefit. As a further example of the interest shown by Canada it may be mentioned that the Dominion Agricultural Department has instructed the specialist in charge of the Fruit Transportation Department, Major R. L. Wheeler, to visit these Islands. This visit has now taken place and in addition to visiting all the Islands on the eastern route, he has been able to spend several days at the Imperial College and see some of the research work that is being carried on there on bananas and other tropical produce. His visit will act as an additional stimulus and is an indication of the very real interest that the Dominion is feeling in the development of this trade. An interchange of visits between responsible officers of Canada and the British West Indies cannot but be conducive of good results.

THE EDITOR requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

WITCH BROOM CONTROL.

A New aspect of Witch broom Control in Trinidad.

By H. R. Briton-Jones and E. E. Cheesman.

Introduction.

This work, commenced in March, 1930, at the request of the Government of Trinidad and Tobago had as its main object the finding of additional means of controlling Witch broom disease (*Marasmius perniciosus* Stahel) in Cacao with particular reference to the conditions prevailing in Trinidad. The majority of the factors discussed below are however applicable to other countries such as Surinam and Ecuador where up to the present time the disease appears to be much more serious than it is in Trinidad.

The writers have held certain theories in regard to Witch broom disease in Cacao since October, 1928, when the disease was first brought to their notice in Trinidad. These theories were based on the one question of paramount importance, namely, whether the spores of the fungus can infect dormant buds as well as those which are already sprouted. Stahel (12) states that "The grown-through and ordinary Krulloten (*brooms*) originate from infection of buds not yet sprouted. Strong end buds of chupons and of young trees which have not yet branched out and also of strong side-shoots often grow through."

The exact meaning of Stahel's statement is not clear*, but if dormant buds can be infected, the means of control have reached their limit. Indeed it would appear that to cut out a broom-bearing branch six inches below the base of the broom might lead to the production of as many as half a dozen brooms to replace the one since the cutting would stimulate the dormant buds below to grow out into shoots. If previously infected they would produce Witch brooms. The production of Witch brooms behind the cut end occurs quite frequently at the present time, but not, because the previously dormant buds were infected. This will be referred to later. Furthermore, infection of dormant buds would definitely limit the effectiveness of spraying with two per cent. Bordeaux Mixture, which has been described as giving effective control of the disease in Surinam. The effect of spraying with Bordeaux Mixture on the disease is also further discussed below.

* As we are going to press Dr. Stahel informs us in an answering letter that he did not investigate the matter of infection of dormant vegetative buds. He also draws our attention to a publication of his which we had missed (*Bull. No.* 39, *Brijdrage tot de kennis der Krullotenziekte. Dept. van den Landbouw.* Dec. 1919) in which it is shown that (*i*) the infection of the ovary can only take place through stomata which develop after fertilisation. It is highly improbable that any stomata could be exposed on the dormant buds with which we worked, and hence our findings are in accord with his (*ii*) green brooms can produce sporophores (mushrooms). *Vide* pp. 4 and 11 in this article. *Bulletin* 39 does not otherwise affect this article.

Infection Experiments.

The following method was adopted for deciding whether dormant buds are infected by *Marasmius perniciosus* :— Some hundreds of Cacao seedlings which had been raised in bamboo pots were transplanted out in beds of about 40 seedlings each in an established Cacao plantation at St. Anna Estate, Cumuto. These young nurseries were kept free of weeds by hand cultivation and no further treatment was given until they had started to make fresh growth thereby indicating that they had recovered from the shock of transplanting. The young plants varied in height roughly from twelve inches to two feet. When required for inoculation experiments they were cut back to about half their height and just above one or two dormant buds. Some of these were inoculated at intervals of one week, two weeks, and three weeks after cutting back. In each case controls were kept. Thus buds were inoculated at various stages, namely, dormant, swelling, bursting and growing. Inoculation was done by applying a gill of a fresh sporophore (mushroom) actually on to the bud in the case of those in a dormant and swollen condition and between the stipules and young leaves in the case of those bursting and growing. The gill was then sprayed with water by means of an atomiser and in some cases covered with a large test-tube which had been previously sprayed with water to wet it on the inside. In others the shoots were left uncovered.

Inoculation Series No. 1.

All the Cacao seedlings in this series were cut back on the 27th June, 1930, as described above. Whilst inoculation was being carried out heavy rain fell on each occasion.

No. of Bed Rows.	No. of plants	Date cut back.	Date Inoculated.	Date finally exam'ed.	Remarks.
I. 1	4	27/6/30	27/6/30	19/9/30	No brooms.
I. 2	4	do.	Control	do.	do.
I. 3	4	do.	27/6/30	do.	do.
I. 4	4	do.	Control	do.	do.
and so on for 10 rows.					
II. 1	4	27/6/30	2/7/30	19/9/30	No brooms.
II. 2	4	do.	Control	do.	do.
II. 3	4	do.	2/7/30	do.	do.
II. 4	4	do.	Control	do.	do.
III. 1	4	27/6/30	4/7/30	19/9/30	No brooms.
III. 2	4	do.	Control	do.	do.
and so on for 9 rows.					

Inoculation Series No. 1.—*Continued.*

No. of Bed Row.	No. of plants.	Date cut back.	Date Inoculated.	Date finally exam'ed.	Remark.
IV. 1	4	27/6/30	11/7/30	19/9/30	2 brooms 1 healthy 1 doubtful.
IV. 2	5	do.	Control	do.	No brooms.
IV. 3	5	do.	11/7/30	do.	2 brooms.
IV. 4	5	do.	Control	do.	No brooms.
IV. 5	3	do.	11/7/30	do.	No brooms.
IV. 6	4	do.	Control	do.	No brooms.
IV. 7	3	do.	11/7/30	do.	2 brooms.
IV. 8	4	do.	Control	do.	No brooms.
IV. 9	5	do.	11/7/30	do.	2 brooms.
IV. 10	3	do.	Control	do.	No brooms. On the 11th July, 1930, buds in first stages of growth but varying between swelling and bursting.

There were 20 plants inoculated in Bed IV of which eight or 40 per cent. were positively infected. Beds Nos. VI, and VII were also cut back on the 27th June, 1930, but inoculations on the 18th July, 1930 and on 25th July, 1930 were not possible owing to the difficulty of finding mushrooms. A period of dry weather had set in which is quite abnormal at this time of the year.

Inoculation Series No. II.

Four additional beds were treated in a similar manner to those in Inoculation Series No. I. All plants in the four beds were cut back to dormant buds on the 22nd September, 1930.

Bed No. I.—Inoculated 22nd September, 1930. This consisted of ten rows of ten plants each. Rows I, III, V, VII, IX inoculated as in Series No. 1., sprayed with an atomiser but not covered with a test-tube. Rows II, IV, VI VIII, X served as controls. Examination on 21st November, 1930, showed that all shoots from inoculated and controls were healthy. No Brooms.

Bed No. II.—Inoculated 26th September, 1930. Rows I, II and III, 4 plants each. Inoculated. Covered with test-tube for 24 hours. Test-tube then removed. Rows IV and V, 4 plants each. Controls. No brooms on 21st November, 1930.

Bed No. II.—Inoculated 3rd October, 1930. Most of the buds showing signs of swelling. Rows VI, VII, and VIII, 4 plants each. Inoculated. Not covered with test-tube. Rows IX and X, 4 plants each. Controls. No brooms on 21st November, 1930.

Bed No. III.—Inoculated on 10th October, 1930. Some of the buds were swelling, some bursting, and others actually growing. In the following table-diagram the inoculated buds are indicated thus :—

B=bursting, G=growing and B/G=a stage intermediate between B and G. Those marked S served as controls although in swelling stage only.

Row I	....	—	S	G	S
Row II	....	B	B/G	B/G(B)	S
Row III	....	S	G	G (B)	—
Row IV	....	S	B	S	B
Row V	....	S	S	B/G	G (B)
Row VI	....	S	S	G (B)	S
Row VII	....	S	S	S	S
Row VIII	....	S	B	B	G
Row IX	....	S	S	S	S

All plants sprayed with water. A shower of rain fell immediately after inoculations had been completed. On 21st November, 1930 those showing brooms are marked (B). No. inoculated=14. Number of positive infections=4.

Bed No IV.—Inoculations on 17th October, 1930. Procedure as in Bed No. III. Controls varied in condition ranging from B, B/G to G. Inoculated buds as indicated.

Row I	B/G	B/G	G	G
Row II	Not included	Not included	G	G
Row III	G	B/G	B/G	Not included.
Row IV	B/G	B/G	B/G	B/G (B)
Row V	B/G	B/G	B/G	B/G
Row VI	Not included	B/G (B)	G	B/G
Row VII	Control	Control	Control	Control
Row VIII	Control	Control	Control	Control
Row IX	Control	Control	Control	Control

Positive infections 2 indicated by (B). No. of inoculations 20.

Note—The results in Inoculation Series No. II are not conclusive because at the time of inoculation of Bed I, II and IV the weather was dry so that failure of inoculations in Beds I and II might quite easily be due to unfavourable conditions.

Inoculation Series No. III.

Twelve young Cacao plants growing in bamboo pots were cut back to dormant buds. By the 28th November, 1930, these had produced shoots varying in length between one to two inches, and at 3 p.m. were inoculated as in Inoculation Series I, sprayed with water, and covered with a large test tube. At 10 a.m. on the 29th November, 1930, the tubes were carefully removed, the plants again sprayed, and tubes replaced as before until 11 a.m., on the following day when they were finally removed. On the 28th November, 1930, ten more young Cacao plants in bamboo pots were cut back to dormant buds, inoculated at 3 p.m. by placing half a mushroom on the dormant buds near the cut end. These were kept in place by wrapping in moist cotton wool which was then thoroughly wetted by spraying with water. They were then covered with test-tubes and further treated as in the case of the above 12 plants.

WITCH BROOM CONTROL.

PLATE I.

FIG 1.—*Inoculated Plants with growing shoots in Inoculation Series III on 17th December, 1930, showing first stages of broom development. Left to Right, Plants IX, X and I.*

FIG. 2.—*Inoculated Plants in Inoculation Series III on 3rd January, 1931. Left to Right, Plant II of series inoculated with buds in dormant stage-shoots normal. Plant X and Plant I as in Fig. 1.*

WITCH BROOM CONTROL.

PLATE II.

FIG. 1.—*As in Plate I, Fig.* 1. *Plant X on 17th December,* 1930.

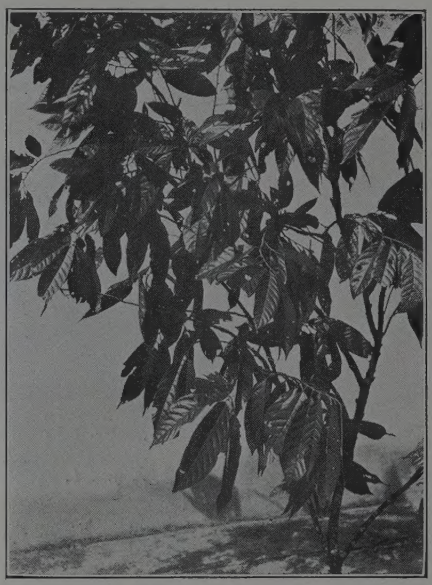


FIG. 2.—*A branch of Cacao tree showing marked variation between size of leaves on lower and upper sub-branches. Note thicket of growth at top.*

FIG. 3.—*Left—sub-branch of branch in Plate I I, Fig.* 2. *Right—Branch from same tree. Note the differences in the sizes of the leaves on the two branches.*

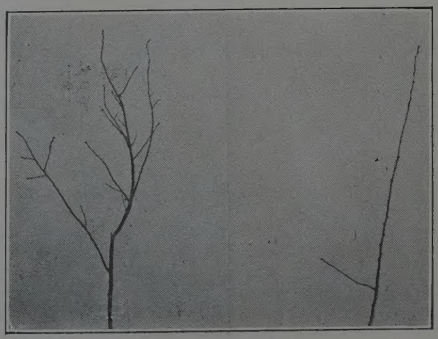


FIG. 4.—*As in Fig.* 3 *with leaves removed. Note difference in numbers of growing points. Branch on left which had small leaves has* 21 *growing points whereas branch on right has only two.*

The following records observations carried out on the foregoing plants:

Plants with Growing Shoots inoculated on 28th Nov.

No. of Plant.	No of. Shoot.	Date. 5th Dec., 1930.	Date. 12th Dec., 1930.	Date. 17th Dec., 1930.	Date. 22nd Dec., 1930.	Date. 28th Dec., 1930.
I	1	Apparently healthy	Top inch slightly swollen. Broom	Broom	Broom	Broom
	2	Do.	Apparently healthy	Apparently healthy	Broom	Broom
II	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy
III	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy
	2	Do.	Top ¾ inch slightly swollen. Broom	Broom	Broom	Broom
	3	Do.	Top ½ inch slightly swollen. Broom	Broom	Broom	Broom
	4	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Broom
IV	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Broom (2nd January, 1931)
	2	Do.	do.	do.	do.	Broom
V	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy
2	2	Do.	do.	do.	do.	Broom
VI	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Broom
	2	Do.	Top ½ inch slightly swollen. Broom	Broom	Broom	Broom
VI	3	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy
VII	1	Do.	Apparently healthy	Apparently healthy	Broom	Broom
	2	Do.	do.	do.	Broom	Broom
VIII	1	Do.	Top inch slightly swollen. Broom	Broom	Broom	Broom
	2	Do.	Apparently healthy	Broom	Broom	Broom
IX	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy
	2	Do.	do.	Broom	Broom	Broom
X	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy
	2	Do.	Axillary buds swollen	Broom	Broom	Broom
	3	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy
XI	1	Do.	Top ¾ inch slightly swollen. Broom	Broom	Broom	Broom
	2	Do.	do.	Broom	Broom	Broom
XII	1	Do.	Apparently healthy	Apparently healthy	Apparently healthy	Apparently healthy

Total number of shoots on 5th December, 1930 = 26.
Do. do. brooms on 5th December, 1930 = Nil.
Do. do. brooms on 12th December, 1930 = 6 + 1 ? (Plant × Shoot 1).
Do. do. brooms on 17th December, 1930 = 10.
Do. do. brooms on 22nd December, 1930 = 13.
Do. do. brooms on 28th December, 1930 = 16.
Do. do. brooms on 2nd January, 1931 = 18.

The foregoing results show that a shoot may be infected for several weeks before it shows any external symptoms in the form of a swelling of the stem or axillary buds. The length of time between inoculation and recognition of the first symptoms of broom formation depends on the rate of growth of the shoots. A rapidly growing shoot shows the symptoms comparatively soon whilst a slow growing shoot must make a certain length of extension growth before the swollen stem is produced and becomes discernible. The significance of this observation will be discussed later.

Two of the ten plants whose buds were inoculated at dormancy failed to make any growth. This failure of a certain number of plants cut back in the same manner and not inoculated is quite common. The remaining eight plants produced between them a total of 15 shoots all of which grew perfectly normally and with no sign of swelling of the stem throughout the experiment. (*Vide* Plate 1 Fig. 2.)

The results of the above inoculation experiments show that dormant buds cannot become infected by the spores of *Marasmius perniciosus*. Only those which have already made growth can become infected.

Laboratory Experiments with Brooms.

On the 14th March, 1930, bundles of brooms were placed in a series of desiccators containing water to which had been added 10, 15, 20, 25 and 30 per cent. sulphuric acid. In this manner the brooms were constantly kept under different degrees of humidity ranging from 100 per cent. to about 75 per cent. In a few days all the brooms showed a whitish growth of saprophytic fungi belonging mainly to the genus *Fusarium*. It was, therefore, decided to divide the bundle in each of the desiccators into two. One half was dipped daily for a few seconds in alcohol acetic in order to keep down surface fungus weeds. The other half was left untreated. Both treated and untreated were kept in the desiccators for over seven months but during this lengthy period there was no sign of sporophore (mushroom) production by the Witch broom fungus. It was then decided to subject the bundle, which had been treated with a fungicide and kept at approximately 90 per cent. humidity, to intermittent but prolonged showers of tap water from a spray nozzle in the laboratory. At the end of a fortnight one of the brooms produced three mushrooms the smallest of which measured about half an inch and the largest almost an inch in diameter. A week later another broom from the same bundle produced one mushroom about three quarters of an inch in diameter. This is the first time this fungus has been induced to produce fructifications under laboratory conditions. It appears, therefore, that atmospheric humidity is not the factor which governs sporophore production. It has been conclusively demonstrated that this occurs only when brooms are subjected to frequent showers of rain or tap water.

An experiment was carried out in the field to ascertain whether brooms which had been removed from the tree whilst in a green state could produce mushrooms. For this purpose bundles of green brooms and brown brooms were placed separately on the ground at weekly intervals to see whether there would be any difference between the green and the brown brooms in regard to mushroom formation and to ascertain the period of time for the production, if any, of mushrooms. This was continued for three months and no mushrooms were produced on either the brown or green brooms. At the end of this period all the bundles were unfortunately inadvertently destroyed.

It is important to find out whether green brooms can possibly under any conditions produce mushrooms. A negative result would reduce considerably the cost of present control measures and would stimulate planters to cut green without the additional expense of collecting and destroying. It was also desirable to ascertain whether brown brooms require a resting period with or without rain before they produce mushrooms in wet weather. Up to the present no conclusive results have been obtained in regard to these two points. In view of their importance in connection with the control of Witch broom disease they will, however, be thoroughly investigated later.

The longevity of the life of the broom is indicated by the fact that after a period of over seven months they are still able to produce mushrooms.

Effect of Weather Conditions.

Records of the incidence of Witch broom collected by the Department of Agriculture of Trinidad and Tobago as well as those kept by individual planters show that there is a sudden increase following the breaking of the rains in May or June which continues in a general way until the "petit carême" (Indian Summer) in September and October. During the "petit carême" the weather is drier and this is accompanied by a sudden drop in the numbers of brooms found in affected areas. Later, when this short dry period is over there is again a sudden increase in the number of brooms. As already pointed out by Stahel (12) in Surinam and Stell (14) in Trinidad this sudden increase and decrease is due to the fact that the sporophores (mushrooms) of the fungus are not produced under dry conditions.

This is the direct effect of weather conditions on spore production—one factor essential to the spread of the disease. Besides this, the advent of the rains in May and June brings about, in Cacao as well as in other plants, a flush of growth which involves the bursting of buds which have hitherto been dormant. These buds, on developing, become for the first time liable to infection. The number of dormant buds which grow out at this time depends on several factors. Cacao in Trinidad defoliates during the long dry season and generally speaking this

is followed by a flush of growth about six weeks later. If the dry season is prolonged the amount of extension growth and the period during which this takes place is less than under more favourable soil moisture conditions. When the rains in June follow such a dry period there is a sudden uptake of water by the roots and the response to this by the Cacao is not confined to the further production of extension growth, but it also stimulates into growth the dormant buds behind the growing points. Thus the production of sporophores at the commencement of the wet season coincides with the stimulation into growth of dormant buds which then and only then become liable to infection.

Defoliation.

It has already been stated that the incidence of Witch broom depends to a large extent on the time at which Cacao produces a flush of new growth. This is not wholly but is to a great extent preceded by partial or complete defoliation about six weeks earlier. The date of defoliation although occurring in a general way more or less at the same time over large areas does, nevertheless, vary to no mean extent between different estates and between individual trees even in the same field on the same estate. It is not proposed to attempt to explain all the reasons for this variation but there are certain important factors which contribute to it and which cannot be passed over without comment. One of the main group of factors one can indicate under the complex term "Soils." The plural "Soils" is used to focus attention on the various types of soil on which Cacao is being grown in Trinidad. In addition to the intrinsic properties of the various types of soils which influence to different extents the amount and time of growth of Cacao, must be considered the management of these soils. Planters differ in their opinions as to the treatment these soils should be given. Interlocked with this to a great extent is the question of finance since one attorney in charge of half a dozen estates can give good treatment to the soil on one or two, but is forced by economic pressure to neglect the others against his better judgment from the agricultural point of view. In addition to the matter of type of soil the following factors which are discussed below and which, it must be remembered, often interact on each other, also influence defoliation in Cacao: drainage, windbreaks, shade, humidity, thrips, pruning, type of tree and position of estate in relation to prevailing winds.

Drainage.

Went, van Hall, Drost, Stahel (12) and Stell (14) are agreed that an improved system of drainage would not have a *direct* beneficial effect in reducing the incidence of Witch broom since the disease affects both strong and weak trees. They also point out however that it would make the Cacao trees more tolerant to the cutting out of brooms. The present writers agree, but consider that good drainage is of far greater importance in its influence on the incidence of Witch broom than is thought by the above mentioned workers. When Witch broom first appeared in Trinidad it was stated (7) that the disease occurred mainly on low lying ground with a rainfall of about 100 inches and that the disease was worse near the river banks. The reason for this was due to the fact that the river took its course along the lowest points so that the Cacao growing on the banks was not so well drained since in the months of heavy rains the river overflows its banks. Coupled with the fact that the trees on the banks were not so well drained comes the important factor of humidity within the Cacao crop. The humidity of the atmosphere within the Cacao crop is much higher on poorly drained land than on similar land with the same rainfall but well drained. This means that the brooms remain wet for a longer period after a shower of rain. Experience has shown that the longer the period during which brooms are kept wet with water, the sooner will they produce mushrooms. Furthermore, evidence goes to prove that the mushrooms and spores cannot withstand desiccation for any length of time so that any factor which appreciably increases the rate of evaporation of rain water is of importance. One of these factors is good drainage. The weather in Trinidad in the rainy season is showery with intermittent spells of bright sunshine. The spores of the fungus will germinate in water in about thirty minutes and these in order to produce infection of shoots must germinate between the youngest unfolding leaves at the growing points. The youngest leaves bear numerous capitate hairs which tend to hold up the rain water and dew. In an atmosphere of high humidity they would keep wet for a longer period than in a drier atmosphere. In other words the influence of good drainage on the microclimate of the growing points is of great importance in connection with this disease.

As will be shown later the writers are also convinced that it is a factor of much importance in controlling the disease on account of its influence on the type of growth made by the Cacao trees. They wish to point out that the prevailing idea that the deeper the drains the better the drainage system is quite erroneous. It must be remembered that a dry season follows the wet. Deep drains may lead to excessive drying out in the dry season and so cause much more damage during this period than benefit in the wet season. In other words maximum draining is not the optimum. For more detailed discussion on this point the reader is referred to (2) in the list of references.

Shade.

Before discussing the vexed question of shade in Cacao the writers hasten to state that no change of shade conditions should be contemplated in

Trinidad until it has first been decided not only that the best practicable method of drainage has been put into operation, but that sufficiently long a period be allowed to elapse for the Cacao trees to respond to the change. Further, as already stated by Stell (14) no drastic reduction of shade should be made in one season. Drains should not be deepened more than nine inches or so in any one season, particularly on heavy clays. Any drastic and sudden changes will be followed in some cases by the death of certain of the Cacao trees and in others by attacks of Thrips (1) and dying back of branches.

Concerning the general question of shade in Cacao, Nowell (9) states as follows: "These effects of rainfall, of depth of soil, and of dry seasons all depend on the conservation of moisture, and to some extent this is capable of being artificially regulated by the traditional method of growing trees for shade. The question of shade or no shade is often debated as though it were capable of a single and universal answer, whereas it depends entirely on local, and sometimes very narrowly local conditions."

The truth of the above statement is appreciated by a great many, but nevertheless there are others who will persist in advocating the reduction of shade under conditions of soil and exposure to wind which the Cacao cannot tolerate. The exact effect of light on plants is not so far completely understood. Reduction of shade increases the amount of light not only in intensity but in daily duration, and so changes the photo-periodicity. It also reduces the atmospheric humidity within the crop, thereby causing increased transpiration. This means that more water is taken up from the soil per unit of transpiring surface. There may, however, be a compensating factor introduced at this stage on account of the differences in texture in the leaves of Cacao produced under heavy, light or no shade conditions. It must also be borne in mind that shade trees take up water. These factors are compensating in their effect on Cacao in both wet and dry seasons although in different directions. The influence of shade on atmospheric humidity is of much importance since several kinds of plants in Trinidad show symptoms of temporary wilting before the available soil moisture is materially reduced. This is particularly noticeable when the humidity is low and when a breeze is blowing. There is also the possibility that the differences in the temperatures of soils under shaded and unshaded Cacao may be of considerable importance.

The above points are raised to indicate in part the writers' appreciation of the gaps in knowledge at the present time in regard to shade requirements in Cacao as well as other crops. Apart from wind breaks and the correct situation of the Cacao with respect to the prevailing wind, one of the main requirements before reducing shade is the improvement of the soil conditions. Otherwise it is quite probable that reduction of shade will result, with or without the aid of Thrips, in defoliation followed by a flush of growth just at the wrong time of the year, thereby increasing the amount of Witch broom disease immediately afterwards, although at certain other periods of the year the incidence may be reduced. A critical time in this respect is the "petit carême." Indeed if by improvement of soil conditions it were possible to avoid defoliation in the "petit carême" and to produce defoliation in the long dry season only it would do more towards the control of Witch broom disease than anything which has so far been done. The writers are of the opinion that this is possible to a great extent since individual trees which are growing in good soil do this at the present time. Reduction of shade which would then be possible would also probably materially change the amount and ratio of soil micro-organisms which would increase the fertility of the soil. The writers also wish to point out that much can be done to keep down the height of the Cacao trees by lifting the heads of the shade trees by pruning.

Spraying.

The several investigators of Witch broom disease are somewhat divided in their opinion as to the effects of spraying against the disease. Van Hall and Drost (12) found no beneficial result and this they attributed to the impossibility of reaching all parts of the trees and to the fact that Cacao formed new branches during most of the year. They, therefore, advocated pollarding (inkappings-methode) as a means of control. Ter Laag (12) on the other hand claims that by spraying and by removing the diseased parts, he succeeded in getting an estate almost free from the disease without pollarding. Rorer (12) concluded that spraying with Bordeaux Mixture as was done by ter Laag was a more rational method of control than the pollarding of the trees. Stahel (12) on the other hand recommends (*i*) thinning out of branches, especially in the inside of the crown; (*ii*) cutting out and destruction of diseased parts. Stell (14) considers that in the dry season, after collecting the Witch brooms, "stone" pods and diseased cushions, it should be sound policy to spray the trees with Bordeaux Mixture or other fungicide should one more effective be forthcoming. When there are two definite schools of thought concerning a matter of this kind, the writers have frequently found that there is an element of truth in both views and that what is most required is to give an explanation of the different findings. In this case both sets of workers have considered the effect of the application of Bordeaux Mixture on the fungus only and not its important effect on the host plant Cacao. The writers agree entirely with Van Hall and Drost on the impracticability of spraying with Bordeaux Mixture against Witch broom disease for the reasons put forward by these authors. Spraying against the fungus to be effective would have to be done in the wet season when the spores are

numerous. It is obvious that if an extensive spraying programme—and no other would meet the case—were undertaken in the wet season that most of the spray would be washed off before it even dried on the trees. Now that it has been established that dormant buds cannot become infected it is difficult to understand the object of spraying in the dry season against a fungus which produces but few spores at that time of the year. Weather conditions would effectively control the spread of the disease and the time and money spent in spraying, would be far more beneficially spent on the removal of brooms as is at present being done in Trinidad. On the other hand, it is quite conceivable that spraying with Bordeaux Mixture at the beginning of the dry season might give beneficial results. One of the effects of spraying plants with Bordeaux Mixture is to make the leaves a darker green and prolong their life. This is true of Cacao and would, in the short dry season, effectively reduce the amount of Thrips damage and consequent defoliation and later flush of growth with the coming rains. Spraying at the beginning of the long dry season would further tend to make Cacao carry its leaves well into the dry season so as to produce its first main flush at the height of the dry season when spore production is at its lowest. The writers whilst putting these points as an explanation of ter Laag's good results with Bordeaux Mixture do not advocate its use either as a direct or indirect method of controlling Witch broom disease. Spraying Cacao is expensive, difficult, and in the majority of cases the labour and water supply are not available to carry it out to any extent. The chief objection to it, however, is that it merely begs the question and tends to cloak over the fundamental and inevitable issue, namely, the improvement of the soil. When the soil is improved, the root range of Cacao will be deepened on account of improved drainage when heavy rain is falling. This in itself will mean increased tolerance to drought conditions by the Cacao and when coupled with the increased retentiveness of moisture by the soil its effect will be enhanced. Furthermore, effective drainage systems which are now impossible in many cases will become a practical possibility and reduction of shade which is admittedly beneficial for many reasons where possible will be tolerated by the Cacao under improved soil conditions.

The writers have investigated spraying as a means of obtaining universal defoliation at the right time in the dry season. This has not met with any success because like Arabian Coffee, Cacao in leaf can withstand high concentrations of winter washes as used in temperate climates.

Type of Tree.

Stahel (12) states that "The Surinam Cacao trees are not all equally susceptible to the disease. There are individual trees which always have more Krulloten than others. Whether this peculiarity is hereditary is unknown. I do not think it advisable to select the less susceptible varieties, as it would be more profitable to search for the best bearing trees, without regard to Krulloten which we can control successfully."

Jacquet (6) puts forward the view that infection largely depends upon the physiological weakness of the trees and in support of this describes in some localities serious attacks on poorly grown trees in the wet season when the thin layer of fertile soil became waterlogged. He also records that in certain highland regions in Surinam and French Guiana, where good methods of cultivation are practised and the trees are mostly without shade, the disease is unknown.

Ciferri (20) describes an economically unimportant disease of Cacao tentatively called 'roncet' because of its external similarity to 'roncet' or 'court noue' of the vine. The young shoots on affected trees grow very little and have very small leaves which never reach normal size, though comparatively long and thin twigs may be formed resembling witches' brooms and bearing a few small leaves. The most apparent symptom at an advanced stage is a reduction in the number of leaves, which are clustered at the tips of the branches and gradually shrivel in the interveinal spaces. Such trees may still produce flowers but generally they do not set fruit or the young fruit becomes mummified. The author considers the trouble to be of a degenerative type.

The above observations by Stahel, Jacquet, and Ciferri have much in common with what has been observed by the writers in Trinidad. On the other hand, there are important differences between the conclusions drawn by Jacquet and Ciferri and the writers. In order to facilitate the explanation of these differences it is considered desirable in the first place to state some fundamental truths in regard to many fruit-producing plants such as the Tomato, Coffee, Apple, Pear, Avocado Pear, Citrus, Gooseberry, Mango, &c., and to give evidence that this is also true of Cacao.

The facts are as follows :—

(*a*) Plants which are growing under conditions conducive to the production of only a small amount of vegetative growth are unfruitful.

(*b*) Plants which are growing under conditions conducive to the production of a medium amount of vegetative growth are fruitful.

(*c*) Plants which are growing under conditions conducive to the production of a large amount of vegetative growth are unfruitful. In other words it is possible to grow a crop like Cacao under too poor and too rich conditions of growth for the continued production of the maximum amount of fruit.

Adverse conditions for growth have a definite effect on Cacao trees in that the leaves become very much more numerous per unit length of branch and at the same time are very much smaller in size. Coupled with this is the shortening of the internodes and an increase in the number of side branches produced, so that the whole

tree has the appearance of a Witches' broom as the term is applied generally to the phenomenon in plants other than Cacao. Given then two trees of equal size above the ground, the good bearing tree will have larger although fewer leaves, longer internodes and fewer branches so as to give the impression of more open formation. The weak tree in comparison will have many short spindly branches bearing small leaves. This means that per unit area of surface above ground the weak tree will have a far greater number of growing points than the good tree and therefore has of necessity an equally greater number of possible infection points. In addition to the fact that they are, therefore, more liable to become infected with Witch broom disease can be added the all-important fact that they are what one might call non-thrifty trees, that is, they do not bear as heavy crops as the trees with open formation and large leaves. Another factor which is of great importance is that these non-thrifty trees are generally left unpruned because planters consider that there is nothing on them worth pruning, and that a good many will die if hard pruned. Such trees as a group would come under class A above and in a class intermediate between A and B, namely A/B. In other words individual trees vary enormously in degree of poverty and further the cause or causes of poverty may be different. For instance there are Cacao trees which have numerous spindly branches with small leaves which are yellowish green in colour, others are similar in appearance except in one important point, namely, the small leaves are dark green; and again there are Cacao trees one branch of which bears fruit and larger leaves and will be classified as B whilst the other branches have small dark green leaves and numerous side branches.

It is desirable at this stage to point out that the genetic constitution of different varieties of Cacao may govern to an appreciable extent the size and type of growth as well as make for greater metabolic plasticity, or in other words greater tolerance of unfavourable soil and other conditions. These are of great importance in Cacao as in other crops and are receiving the attention of one of the writers at the present time. On the other hand the writers consider, in view of the evidence given below, that a large percentage of the Cacao trees in Trinidad belong to Class A and the intermediate Class A/B because they are growing under unfavourable conditions particularly in regard to soil and pruning.

Ring-Barking.

One of the four branches on a young Cacao tree which had not previously produced a crop was ring-barked in the first week of November, 1930. When examined in the first week of January, 1931, the branch which had been ring-barked together with its sub-branches were bearing many blossoms. Those branches which had been left untreated showed no trace of blossom. This shows that a check given to a rapidly growing branch will throw it into a fruiting condition. In other words, the ring-barked branch was converted from the Class (C) type to the Class (B) type described above.

Size of Leaf.

Plate II Fig. 3 shows two branches taken from the same tree. Similar instances can be seen on a very large number of trees throughout Cacao estates in Trinidad. This shows that in the majority of cases small size of leaf is due to conditions of growth and, therefore, modifiable.

Inoculation Period.

Inoculation Series III shows that there is marked variation between the date of inoculation and the development of a broom on different branches. This has been shown to be correlated with rate and strength of growth. The variability in the period of inoculation between infection and appearance of the broom is of importance since it means frequent inspections by the Witch broom gangs on estates. In other words, although not so serious, it tends in the same direction as would be the case if dormant buds were capable of infection. On the other hand, it will be readily appreciated that trees in a state of crop production (Class B) will be very much less affected in this way than trees in Classes A and A/B, because the side shoots will be fewer and stronger. For the same reason trees in Class C will be less affected even than Class B.

The above leaves no doubt that by adequate treatment it is possible (*i*) to induce a large number of Cacao trees which on first glance might be taken as a genetic type to make new and a more desirable type of growth and (*ii*) to cause partial inhibition of vegetative growth thereby inducing the Cacao trees to produce fruit. The number of Cacao trees in Trinidad which can be classified as A and A/B is surprising and apart from Witch broom disease it is evidently very desirable to bring back or convert such poor trees to bearing condition. In regard to the incidence of brooms on good and poor types of trees the following points are significant:—

(*i*) Trees which are actively vegetative have comparatively few growing points. Other things being equal such as time of defoliation, &c., the incidence of brooms on these trees is proportional to the number of growing points.

(*ii*) Trees which are in a cropping condition have a medium number of growing points which make a medium length of growth. Other things being equal the incidence of brooms on these trees is proportional to the number of growing points. As a class they are more badly affected therefore, than (1).

(*iii*) Trees which are weakly vegetative but non-excessively so have a larger number of growing points than (*i*) and (*ii*). Other things being

equal the incidence of brooms on these trees is proportional to the number of growing points. As a class they are more badly affected, therefore, than (*i*) and (*ii*).

(*iv*) Trees which make but little or no vegetative growth have a larger number of growing points than (*i*) and (*ii*) and fewer than (*iii*). In spite of this, incidence of brooms is less than on (*i*), (*ii*), and (*iii*) since vegetative growth is essential before brooms and incidentally pods can be produced.

(*v*) Cacao trees in lastro (secondary bush) are less liable to Witch broom infection because (*a*) they are protected by a heavy canopy of vegetation which protects them from falling spores and (*b*) they do not defoliate so frequently as Cacao under cultivation. Another point in regard to the poor types of trees (*iii*) is that they produce weak spindly growth and therefore small brooms also which are very difficult to find in the thicket of branches on such trees. The swollen brooms on the more robust trees (*ii*) with open formation are more easily detected by the inspection gang.

Pruning.

Went (12) stated that on estates where the trees are pruned, comparatively few brooms are found. Stell (12) has pointed out, that annual pruning is beneficial in Cacao cultivations in Trinidad. There are several methods of pruning practised and these methods vary in degree as well as in time of application. Very good results follow the practice of pruning when carried out along certain lines under close supervision. On the other hand the pruning is done in terms of fields of Cacao rather than in terms of individual trees. That is, the same method is often carried out in the same manner irrespective of the fact that not only does each tree require to be judged as an individual in its requirements but also each branch with reference to other branches on the same trees. As with the majority of other plants there is no hard and fast method possible and what must always be done is to apply certain principles with judgment and discretion. The general tendency in the island is, however, to prune too lightly and later to thin out the side branches either too drastically or not at all. Thinning out of branches some months after pruning in the long dry season is essential, but this must be done with judgment. In connection with Witch broom disease, it is necessary in this thinning to do so in a manner which will effect the minimum amount of new growth subsequently produced. The less new growth of side branches produced in the wet season the fewer the number of vulnerable growing points. When pruning established Cacao plantations it is necessary to consider also the interval at which the trees have been planted. In comparatively young plantations the branches of the trees grow into one another. In avoiding this the practice of lopping off the ends of the branches at the lowest point at which they interfere with the neighbouring tree is quite unsound. This is nearly always followed by the growth of several shoots from the nodes behind. These shoots grow vertically and in the aggregate make too dense a growth. They also tend to fill up the centre of the trees which is admittedly an unsound thing to do on account of Black Pod and Witch broom disease. It is better to thin out some of these branches by cutting back to their bases. If the parent branch is also interfering with its neighbour this should also be cut clean at its base and if the wound is large it should be dressed with carbolineum, brunolinum, or some such effective fungicide. There is nothing to be gained by allowing trees to grow into each other and all effort should be made to keep them within the space allotted to them. Attention is also directed to the necessity after a number of years for the thinning out of trees. The selection of trees to be left could well be based on the types in the plantation rather than to any stereotyped thinning out in regular intervals. This would reduce the amount of Black Pod and Witch broom diseases and so increase appreciably the yield on pathological grounds alone. It would also give the thrifty or high yielding trees remaining, more room for development and therefore heavier production on cultural grounds also apart from the factor of disease.

In dealing with the question of thinning it might be as well to point out that the practice of cutting out brooms at a point six inches or so below the extent of the affected area whilst effectively removing the broom does in many instances do as much harm as good. The cutting as practised is invariably followed by the production of several shoots behind the cut end and time and again the writers have observed that a clump of brooms will be produced on account of the subsequent infection of the young developing shoots. There is no alternative method in some instances particularly in the case of leading shoots but in the case of side branches they should be cut to their bases. This is not followed by so much growth of fresh shoots and in a large number of cases particularly when such growth is young and succulent no new growth will be produced.

It will thus be seen that the following points are of great importance and if followed will be found helpful to planters in deciding their method of pruning. By semi-pollarding is meant the removal of all growth up to one inch in diameter.

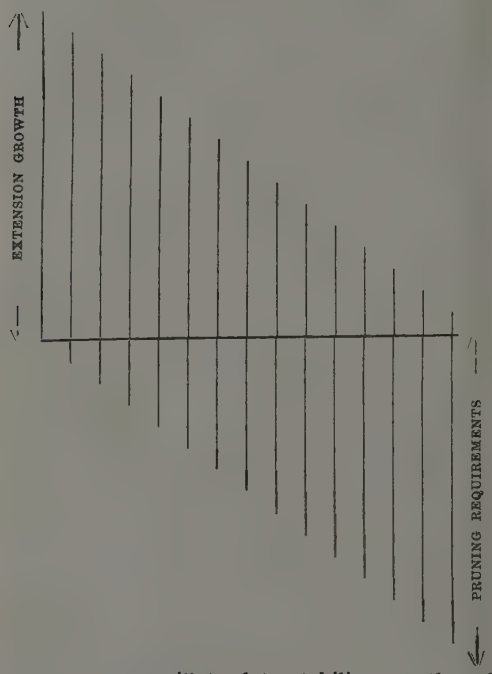
(*i*) If the cacao tree or branch is producing large leaves and vigorous growth, do not prune in the sense of cutting back but thin if necessary by cutting some of the branches to their bases. Do not manure.

(*ii*) If the Cacao tree or branch is producing large leaves and medium extension growth together with cropping, resort to medium pruning and medium manuring.

(*iii*) If the Cacao tree or branch is producing numerous small dark green leaves and many spindly side branches, subject it to semi-pollarding

or hard pruning whether it is cropping or not and design the future scaffolding of the tree by thinning some months later. Apply manure.

(*iv*) If the Cacao tree or branch is producing numerous small light green leaves and many spindly side branches attention should be first paid to the soil conditions. When these have been rectified by improved drainage, manuring &c., then subject it to semi-pollarding or hard pruning. If pruned before the soil conditions are improved such trees will die. In other words for maximum fruit production and a reduction of Witch broom it is necessary to be able to read tree language and thereby be able to anticipate cultural requirements. *Vide* Diagram.



This system will tend to stabilise growth and pod production thereby reducing cost of picking. Furthermore, if the pruning system advocated by one of the writers (5) be adopted for Coffee it is possible that the clashing of the cropping periods of Coffee and Cacao on estates growing both crops might be avoided thus facilitating labour difficulties. This, however, is a matter which requires further investigation before definite statements are possible.

Suggested Methods of Control.

1. To continue cutting out diseased parts and destroying them. The methods suggested above for brooms borne on side branches would be a definite improvement over the present method of cutting out at a point some six inches behind the base of the brooms for the reasons already given above.

II. The practice of flaming mushroom-bearing brooms by means of sacking soaked in oil, as done on some estates before cutting down the broom is a very sound practice since it checks the distribution of spores from the mushrooms as they fall and are broken into fragments against the branches of the trees.

III. To give attention to all factors which will bring about improvement in the condition of the Cacao trees. Stress is laid on the necessity for improving soil conditions apart from the direct losses caused by Witch broom disease in the form of infected cushions and pods. Black Pod causes much more damage up to the present time. The canker form of this disease also causes immense damage and is one of the main factors which decides the economic age-range of Cacao in Trinidad. A large canker on a limb also causes frequent defoliation. The losses caused by these diseases will be very markedly reduced when the condition of the soil is improved to a point which makes shade reduction possible.

Cacao growing is being extended in other parts of the world where soils have not been exhausted to the extent they have in Trinidad. On the other hand, it will take many years before the knowledge of Cacao growing and preparation reaches in such countries the standard in Trinidad at the present time. It must, however, be recognized that competition is being felt and the only way in which Trinidad Cacao can hold its own and indeed markedly improve its position is by means of more intensive cultivation. By intensive cultivation is not meant necessarily the digging of deeper drains and brushing, since both these operations when done at the wrong time can prove injurious to Cacao. To come within the meaning of "Intensive Cultivation" each operation must result in increased yield. With increased yield and increased quality the high standard of preparation of Cacao in Trinidad as compared with other larger Cacao growing countries will have far greater influence than at the present time.

The problem in Cacao growing is, in the writers' minds, very similar to that which is confronting Coconut planters in Trinidad, except that it is not so difficult in application and is far more likely to yield satisfactory results on a larger scale.

In conclusion the writers wish to point out their appreciation of the fact that to know what to do is not the end of the problem. Another problem still remains for a large number of planters, namely, how to do it. In other words it, to a great extent, resolves itself into an economic problem.

Summary.

I.—Dormant Buds.

Infection experiments are described which show that buds whilst in a dormant condition are not infected by the fungus *Marasmius perniciosus*. Both terminal and lateral growing points are attacked with the result that subsequent extension growth takes the form of a Witch broom. The size (*i.e.*, both length and thickness) of the

brooms so produced depends on the rate and strength of growth after infection. Strong and rapidly growing terminal and side shoots produce long witch brooms which are twice or thrice thicker in diameter than the shoot on which they are borne. Witch brooms which are produced on weak terminal or side shoots are shorter and not markedly swollen, nor is the size of the leaves so markedly reduced.

II.—Sporophore Production.

Laboratory experiments show that the fungus *M. perniciosus* cannot produce sporophores (mushrooms) on Witch brooms when constantly kept in a dry, moist or even saturated atmosphere. In order to bring about conditions conducive to sporophore (mushroom) production the brooms must be subjected to prolonged and frequent wettings with rain or tap water.

III.—Green and Brown Brooms.

The question whether green brooms can form mushrooms is indicated as a most important point for future investigation.

IV.—Weather Conditions.

As wet weather follows dry periods the incidence of Witch broom increases rapidly. This is due to (*a*) increase in the number of sporophores produced by the fungus in wet weather (*b*) the flush of growth in the Cacao when wet weather follows a dry period.

V.—Defoliation.

The time, extent and frequency of defoliation in Cacao is of extreme importance in connection with Witch broom disease since six weeks after defoliation the Cacao produces a flush of growth. There are many factors, which influence defoliation in Cacao including (*i*) Type of soil (*ii*) Drainage (*iii*) Windbreaks (*iv*) Shade (*v*) Atmospheric humidity (*vi*) Thrips damage (*vii*) Pruning (*viii*) Type of tree (*ix*) Position of Cacao in relation to prevailing winds. Each of these factors is discussed.

VIII.—Spraying.

Spraying Cacao trees with two per cent. Bordeaux Mixture makes the leaves a darker green and prolongs the life of the leaves. This means less frequent defoliation and fewer flushes, and therefore partial control of Witch broom. Spraying with Bordeaux Mixture is not likely to affect materially the incidence of Witch broom disease on account of its direct effect as a fungicide.

Spraying against Witch broom is not recommended because it is expensive, difficult to apply and in the majority of cases the labour and water supply in the dry season are not available to carry it out to any extent. The chief objection to it, however, is that it merely begs the question and tends to cloak over the fundamental and inevitable issue, namely, the improvement of the soil. The writers feel that the money spent on spraying if invested in manure to be applied to the soil would give better and more permanent results.

IX.—Type of Tree.

Adverse conditions for growth have a definite effect on Cacao trees in that the leaves become very much more numerous per unit length of branch and at the same time are very much smaller in size. Coupled with this are the shortening of the internodes and an increase in the number of side branches produced, so that the whole tree has the appearance of a Witches' broom as the term is applied generally to the phenomenon in plants other than Cacao. This means that per unit area of surface above ground the weak tree will have a far greater number of growing points than the good tree and therefore has of necessity an equally greater number of infection points. If adverse conditions are allowed to continue beyond a critical point the number of growing points become gradually reduced until the tree dies.

Acknowledgments.

We wish to express our gratitude to all the Officers o the Department of Agriculture of Trinidad and Tobago for their generous co-operation in facilitating the work at all times.

We also wish very sincerely to thank the owners and management of St. Anna Estate for putting a field of Cacao at our disposal without restriction and for their ready help and co-operation at all times.

Bibliography.

1. Ballou H. A.—" Observations on Insect Pests in Grenada " *Bull. Entom. Res.*, Vol. VI, p. 75. 1915.
2. Briton-Jones, H. R.—" Wilt Diseases of Coconut Palms in Trinidad " Part I, Supplement to *Trop. Agriculture*, May, 1928. Part II, Supplement to *Trop. Agriculture*, October, 1929.
3. Briton-Jones, H. R.—" Witch broom disease," *Trop. Agriculture*, VI, 2, p. 57, 1929.
4. Briton-Jones, H. R.—" Witch broom disease, "*Trop. Agriculture*, VI, 1, pp. 20-22, 1929.
5. Briton-Jones, H. R.—" Control of the American Leaf Disease (*Omphalia flavida*) on Arabian Coffee in Trinidad." I.C.T.A. *Memoir No.* 2., *Myco. Series*, August, 1930.
6. Jacquet (J. H.)—" Les balais de sorciere du Cacaoyer et les moyens de les eviter (Witches' broom of Cacao and the means of avoiding it)—*Agron. Colon.*, XVIII. No. 137, pp. 129-133, 1929, (*Rev. App. Myco.* Vol. VIII No. pp. 636, 1929)
7. Freeman, W. G.—" Witch broom in Trinidad " *Trop. Agriculture*, V, No. 11, pp. 287-288, 1 fig., 1928. and Freeman, W. G.—" Witch broom disease " *Trop. Agriculture*, VI, 2, pp. 55-56, 1929.
8. Howard, A.—" The fungoid diseases of Cacao in the West Indies." *West Indian Bull.* page 205, 1901.
9. Nowell, W.—" Diseases of crop plants in the Lesser Antilles " West India Committee, 14 Trinity Square, London E.C. 3.
10. Ritzema Bos.—" Die Hexenbesen der Kakaobaume in Surinam " *Zeitschrift Pflanzenkrankheiten*, Bd. XI, 1901, p. 27.
11. Rorer, J. B.—" The Suriname Witch broom disease of Cacao." Board of Agric., Trinidad and Tobago, *Cir.* No. 10, 1913.
12. Stahel (G.)—" *Marasmius perniciosus*, nov. spec." Department van den Landbouw in Suriname, Bull. No. 33, September, 1925.
13. Stahel (G)—" Witch broom" *Proc. Agric. Soc.* Trinidad and Tobago, XXIX, No. 1, pp. 12-19, 1929.
14. Stell, F.—" Witch broom disease of Cacao and its Control " *Bull. Dept. of Agric.*, Trinidad and Tobago, XXI, No. 3, pp. 3-14, 7 fig., 1928.
15. Van Hall, C. J. J. en Drost, A. W.—" De Krullotenziekte der cacaoboomen in Surinam, haar oorzaak en haar bestrijding. Dep. von Landbouw in Suriname, *Bull.* No. 16, 1909.
16. Van Hall C. J. J.—Cocoa. 1914, page 257.
17. Went, F. A. F. C.—" De ziekteverschijnselen van de cacao plant in Surinam", *S'Gravemhage*, 1903.
18. Went, F. A. F. C.—" Krulloten en versteende vruchten van de cacao in Surinam, verhandelingen der Kon. *Akad van Wetenschappen te Amsterdam* 2 Sectie deel X, No. 3, 1904.
19. Went, F. A. F. C.—"Discussion on Witch broom disease " *Proc. Agric. Soc.*, Trinidad and Tobago, XXVIII, 9, pp. 381-390, 1928.
20. Ciferri, (R).—Phytopathological survey of Santo Domingo, 1925-1929.—*Journ. Dept. Agric.* Porto Rico, XIV, No. 1, pp. 5-44, 2 Pl., 2 Maps, 1930. (*Rev. App. Myco.* Vol. IX, Pt. 8, pp. 510-512.)

CITRUS PROPAGATION.

The Propagation of Citrus by means of the Solar Propagator.

By R. E. Hunter.

The vegetative propagation of citrus varieties by means of stem cuttings has been under investigation for some while at the Imperial College of Tropical Agriculture, as part of the Citrus Research Scheme. The solar propagator, although it has only been in use for a short while, has proved so successful for rooting citrus that it has been deemed worthy of a description of its structure and use, even at this early stage of the investigation.

Objects of Vegetative Propagation.

The extreme variability of seedling plants has long been recognized by practical horticulturalists in both Temperate and Tropical fruit crops. Seedling plants commonly differ very considerably amongst themselves and from the parent plant. Some of the differences most easily recognized are quality of the fruit, early maturity, growth habit, and general vigour. The propagation of definite fruit types has long been achieved by budding and grafting operations, a scion of the desired variety being worked upon a seedling rootstock. To supply the present-day market demands for uniform products, the large scale budding of a single variety upon seedling rootstocks has become commonplace.

This practice ensures uniformity of fruit type, but neglects the possibly variable effects of the seedling rootstocks upon the vigour and growth habit of the scion budded thereon. This aspect of plant propagation, the influence of the stock upon the scion, has of recent years been the subject of much research work in relation to the temperate fruit crops such as Apples, Pears, Plums, &c. The results have shown that the rootstocks may considerably influence the tree size, the time of coming into bearing, and the productivity of the scion budded thereon. If, therefore, a grove of trees of uniform size and productivity is desired, not only must the scions be uniform but also the rootstocks. English fruit growers have not been slow in taking advantage of these researches, and as a consequence at the present day very little budding is still done using seedling stocks. The stocks are all raised vegetatively.

The stock-scion interactions in tropical and sub-tropical fruits have not as yet received a great deal of attention, though Webber (7) has demonstrated the effect of seedling sweet orange stocks when budded to Washington Navel, Valencia Orange and Marsh Grapefruit. He showed that the smaller seedlings in a nursery bed when budded, produced trees that always remained smaller and less productive than those which had been budded on to the larger and more vigorous seedling stocks.

In vegetative propagation we have a means of producing plants of uniform characteristics, and many research papers have appeared in recent years dealing with the technique of vegetatively propagating uniform stocks for the temperate fruit crops. In the Tropics, research on vegetative propagation has again lagged behind that done in Temperate climates, but has recently received more attention (6). Although the Solar Propagator was originally described from Hawaii in 1920 (8), and its utility for propagating citrus was reported on in America in 1924 (5), yet its use does not seem to have become very widely disseminated. In Trinidad a Solar Propagator of simple type has been used for several years by Dr. Harland at the Cotton Research Station, for rooting soft-wood cotton cuttings. That the interest in vegetative stocks for citrus has not been very great has possibly been due to two causes. In the first place, citrus differs from most seed bearing plants in that each seed usually contains several embryo plants. This phenomenon is known as polyembryony. It is no uncommon sight in some citrus species to see from two to five little plants arising from a single seed. However, only one of the embryos in the seed has been produced in the normal manner by sexual processes, the others have all been produced by vegetative budding. In the nursery bed there will be a mixture of plants, some derived from sexual embryos and some from vegetative. Ordinarily it is impossible to distinguish between these two types of plant, although if the parents have been very dissimilar in leaf characteristics, it may in some cases be possible to distinguish the hybrid leaves from those of the mother parent type which are borne on the vegetatively produced plants. This would only happen as a rarity in nature, but might be brought about by artificially cross pollinating all the flowers. It would not be practicable to do this on a sufficiently large scale for commercial purposes. The vegetatively produced plants will theoretically not vary from the parental type, though in citrus we have to recognize the possibility of bud variation, and the variation in a bed of citrus seedlings will therefore not be so apparent as in a bed of seedlings of a plant reproducing itself entirely, as is normal, by sexually produced embryos. The variation of seedling stocks has therefore probably not impressed itself to any great extent upon citrus growers. Secondly, there is a long-standing and wide-spread belief that trees propagated vegetatively only develop superficial root-systems and are short-lived. This has now been abundantly disproved, as far as apples and other temperate fruit trees are concerned, by the work of the East Malling Research Institute and there is no reason why vegetatively produced citrus trees should not be equally satisfactory. The root development of such citrus trees is being carefully observed at the Imperial College.

Vegetative Propagation.

In vegetative propagation a piece of the plant to be propagated is separated from the parent plant and is established as a new individual. As it is simply a portion of the parent, this vegetatively produced offspring reproduces all the parent characteristics exactly. Usually a piece of stem is used in propagation, but it may also be a root piece, and in some cases a leaf. Success depends upon the capacity of an isolated stem to produce roots, and of a root piece to produce buds and finally to grow into a complete new plant.

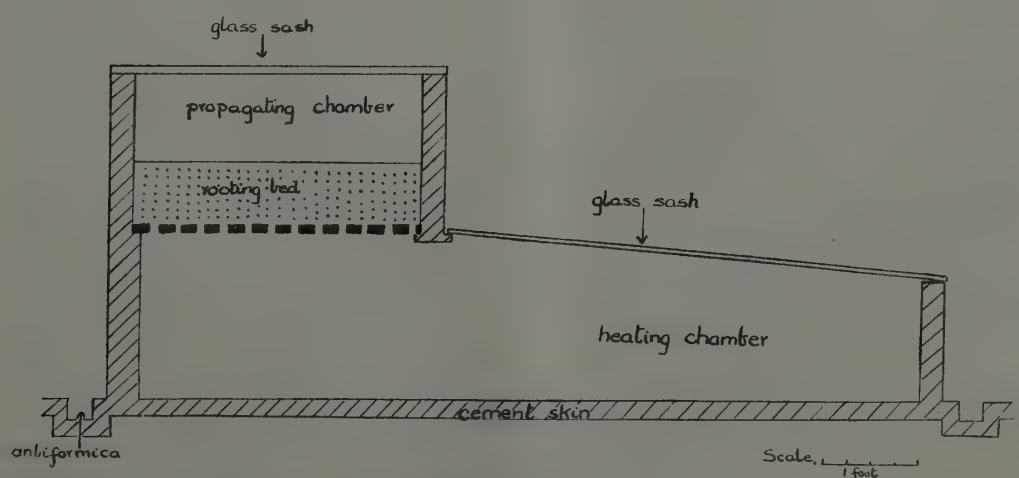
In general, there may be said to be two distinct stages in the successful establishment of a stem cutting as a new plant. Firstly, the cut end must be healed over before fungi and bacteria attack the internal tissues and cause decay and death. In the plant this healing is brought about by the development of a wound tissue or callus, which forms a pad or cushion over the cut end and effectively prevents the entry of decay organisms. Secondly, there is the production of roots which either grow out from the callus or from the stem just above the callus or from both regions. In sour orange the roots are almost entirely limited to the callus region, but in citron, whilst most of the roots arise from the callus, a large number also arise from the stem higher up (10).

It is important, therefore, that callusing should take place as rapidly as possible, and this is where the Solar Propagator is of especial use, for the rate of callusing is much increased by warmth (3), (4). Other factors which are of importance are abundant moisture, aeration, and absence of decay fungi. Moisture is provided for in the Solar Propagator by watering the propagating bed daily and by making the bed in a closed chamber so that the atmosphere remains saturated with moisture. Aeration is also important, but different species of plants vary considerably among themselves in this respect, some requiring a greater and some a lesser degree (1), (2). Aeration of the cut end is made possible by using a fairly coarse sand for the propagating bed. Absence of decay organisms can in large measure be attained by using clean washed sand for propagating as this contains little or no organic matter upon which the organisms thrive and multiply.

The Solar Propagator.

The Solar Propagator is designed to supply conditions favourable to rapid rooting at a minimum of expenditure. In temperate climates it is usual to stimulate rooting by heating up the propagating bed. This is usually referred to as bottom heat and is accomplished by running steam or hot water pipes through the bottom of the bed. Another method is to construct the bed over a heap of decaying dung. Owing to the rapid rate of decomposition, the latter is unsuited for use in the tropics. In the Solar Propagator, sunshine is made to supply the bottom heat. Essentially, the Solar Propagator consists of two compartments, a heating compartment and a propagating compartment. The heating chamber, which is oblong in shape and covered with a glazed sash, serves as a trap for the sun's rays. The air inside the chamber becomes much heated during the daytime. Part of the heating chamber is continuous with the underneath of the propagating bed (*see* diagram) and the hot air impinging upon the under surface of the bed warms it up, thereby supplying bottom heat.

SOLAR PROPAGATOR.



SECTIONAL PLAN.

The area of the heating chamber is approximately double that of the propagating chamber. Two Solar Propagators have been constructed for experimental purposes at the Imperial College of Tropical Agriculture. These differ from most previously described propagators in having all the walls constructed of concrete instead of wood, and in that the heating chamber is a simple extension lying due south of the propagating chamber, instead of being constructed on two or more sides of the heating chamber. This arrangement permits of greater accessibility to the propagating chamber.

The two College propagators differ slightly in their proportions. In the one first constructed, the propagating chamber was made square, whilst in the second it has been made oblong to allow of greater accessibility. The glazed covering sashes of the propagating chambers also differ, the first consisting of a single hinged sash, whereas the second has two smaller sashes (Fig. 1.) In the present note the dimensions and the text figure are of the second propagator.

Around the outside of the propagator runs a concrete moat six inches wide. This is kept filled with water to keep off ants. The walls of the moat have been asphalted to prevent water leaking away and there is a drainage pipe to permit periodical changing of the water and cleaning. The inside measurements of the heating chamber are five feet wide by five feet long, and the lowest wall is one foot three inches in height, the side walls rising to one foot nine inches at their junction with the propagating chamber. The tilt thus given to the glass light is just sufficient to run off rain water. The glass light simply rests upon the walls and can be lifted off for cleaning the glass when necessary. The floor of the propagator has a thin cement skin to prevent the growth of weeds and to facilitate cleaning. The walls at ground level are provided with one inch holes to allow water which runs through from the rooting bed to drain away. Finally, in the heating chamber are placed a number of large stoppered glass bottles. These are painted black on the outside and are filled with water (Fig. 2). They serve to store up heat during the day and give it off slowly at night, thus helping to keep the temperature uniformly high inside the propagator.

The propagating chamber is provided with a ledge at a height of one foot nine inches from the ground, and at the same level iron pipes are let into the wall, serving to support the rooting bed. The rooting bed is constructed as follows:—Resting upon the ledge, and upon the iron pipes, is a sheet of expanded metal, and upon this rest in turn wire netting, copper gauze, and coconut fibre (*see* Fig. 3, which was taken before filling the propagator with sand). The rooting bed is of clean washed sand, six to eight inches deep, which rests upon the fibre.

The cuttings only receive ventilation when the propagator is opened for watering once a day. They also receive a little ventilation from two one-inch holes in the side walls, which were made to allow of the insertion of a thermometer. There are also holes provided for testing the temperature of the rooting bed and of the air underneath the bed. The glass over the propagating bed is kept covered with lawn or some other light material. If there were no covering the leaves of the cuttings would probably be scorched by the sun's rays. At the same time, however, there must be some light to allow the leaves to manufacture food materials. The atmosphere in the chamber must be kept as moist as possible, and to this end the propagator should only be opened for watering once daily, and that in the early morning or evening for as short a time as possible.

The cost of erecting a Solar Propagator of the size described is in the neighbourhood of $90.00. Here I should like to express my indebtedness to the College Engineer's Department for the working out of the constructional details.

The Cuttings.

Suitable cuttings are made from short lateral branches, six to ten inches long. These should have ceased growing in length, and the leaves should have attained a full green colour. Shoots with angular wood are satisfactory. There is no need to take round wood of pencil thickness. They are best cut with a sharp knife with a small "heel" or shaving of older wood of the parent branch. The lower leaves are removed, leaving about six at the upper end. The type of cutting can be seen in figure 5.

Citrus Species Rooted.

At the moment of writing, the following species have been rooted successfully in the propagator, and trials of further species are now in progress.

Species rooted:—

West Indian Lime.
Kusai Lime.
Rangpur Lime.
T. I. Hybrid Lime (9).
Citron.
Sour Orange.

West Indian lime roots very easily in the Solar Propagator, and cuttings of this species are ready for removal and potting up in compost or planting out in a shaded bed in from 20 to 25 days.

The method might prove of great use in the establishment of new lime plantations, as uniformity of type is assured. It will probably be found also that bearing trees are produced in a shorter time from cuttings than from seed, as the small slow-growing juvenile stages of the seedling are eliminated.

Sour orange takes considerably longer than lime to root. Rooting has taken place in about 50 days. Further experiments are in progress to test the possibility of stimulating more rapid

rooting, and it is hoped to report progress in subsequent issues of this journal. The growing of uniform sour orange stocks should be a distinct step forward in the production of uniform orchards and fruit.

REFERENCES.

(1) Knight, R. C.—The Propagation of Fruit Tree Stocks by Stem Cuttings.—*Journal of Pomology and Horticultural Science*, No. 5, 1926.
(2) Rea, H. E.—Callusing of Cotton Stem Cuttings.—*Plant Physiology*, No. 5, 1930.
(3) Shippy, W. B.—Influence of Environment on the Callusing of Apple Cuttings and Grafts.—*American Journal of Botany*, No. 17, 1930.
(4) Swingle, C. F.—A Physiological Study of Rooting and Callusing in Apple and Willow.—*Journal of Agricultural Research*, No. 39, 1929.
(5) Swingle, W. T., Robinson, T. R. and May, E.—The Solar Propagating Frame for Rooting Citrus and Other Sub-Tropical Plants. U.S. Department of Agriculture, *Circular* No. 310, 1924.
(6) ——————The Nurse Grafted Y-Cutting Method of Plant Propagation. *Journal of Heredity*, No. 20, 1929.
(7) Webber, H. J.—Selection of Stocks in Citrus Propagation. *Paper* No. 63, Univ. California Graduate School, Tropical Agriculture and Citrus Experiment Station.
(8) Westgate, J. M.—A Device for Securing Bottom Heat in the Propagation of Cuttings. *Report Hawaii Agricultural Experiment Station*, 1920.
(9) Williams, R. O.—Limes and Withertip. *Tropical Agriculture*, No. 6, 1929.
(10) Zimmerman, P. W. and Hitchcock, A. E.—Types of Root Growth from Cuttings with Special Reference to Position on the Stem.—*American Journal of Botany*, No. 15, 1928.

CORRESPONDENCE.

DIVISION OF ENTOMOLOGY,
FROGHOPPER INVESTIGATION COMMITTEE,
TRINIDAD,
10*th March*, 1931.

TO THE EDITOR OF "TROPICAL AGRICULTURE."

SIR,

My attention has been drawn to an article, reprinted from a letter in *Nature* of March, 1930, in your current number, under the heading "Water Balance in Plants."

While I am not prepared to dispute the general conclusions derived by the authors, I believe the available information as to the causation of Froghopper Blight does not support the authors' views to the extent which might be supposed. As this is a question of some moment, I shall be obliged if you will allow me to clarify the matter in your columns, although a fuller statement of the recent developments of froghopper research on entomological lines is already in the press for publication elsewhere.

The theory that the physiological condition of the cane plant accounts for the susceptibility of some cultivations and for the comparative immunity of others, seems to have been originally prompted by the familiar observation that severe blight often occurs on the red clay soils of the Naparima District, while blight rarely occurs on the black marls of the same district. From this it was suggested that canes growing on the highly acidic clays were in a condition of sub-health, and therefore more susceptible to the same external factors than the supposedly vigorous plants grown on the neutral or alkaline marls

Since the original publication of the letter under consideration, however, work performed in this Division has shown that the froghopper population is very markedly less on the non-blighting soils of the Naparima area, and examination of the soils of other districts where a similar distinction of blighted and blight-free fields can be noted has shown again that there is a corresponding difference in the number of froghopper eggs laid in the soil. This observation holds true even when there is little discernible difference between the reactions, texture and other constants of the soils of the contrasted fields. This has suggested that the density of the froghopper population itself determines the severity of blight, and that the density of the froghopper population depends on the soil being attractive as a medium for oviposition.

By allowing froghoppers to lay in soils of different types and conditions, supplying nourishment of the same kind, Hardy has confirmed this relation between froghopper population and soil characters. These facts manifestly reduce the practical significance of the physiological theory.

Further, there is no definite evidence that the physiological conditions of the host plant affect the production of froghopper blight. Much work has been devoted to this study, without positive results. The late Dr. Withycombe made a tentative suggestion (*Ann. App Biol.* XII) that this was possible, but was not emphatic on the point, as is shown by the remarks interpolated in his account of the experiments, as for example "With additional experiments it was concluded that the results obtained by allowing the insect to suck for a given time were not reliable" and again: "Many more experiments, under better controlled conditions are necessary before any proof can be considered to have been established" (*loc. cit.*, pp. 87-88). Subsequently in a semi-popular paper (*Proc. Agric. Soc.* Trinidad and Tobago, 26, p. 294, 1926), Withycombe is less reserved on this point, but it is doubtful whether he is here considering the *production* of blight or *recovery* from blight, a distinction which cannot be emphasised too strongly. At any rate, no description of the experimental results was given.

It is evident that the severity of blight production must depend on the number of froghopper punctures on the leaves (and therefore on the number of froghoppers per unit of active leaf area) and also on the ultimate extent of the discoloured streaks formed in relation to those punctures. The extent of the streaks may vary with water relations of the host plant and other physiological factors, though there is no evidence that it does so, and also with the volume and concentration of the saliva introduced by the insect and the volume of sap extracted. These latter factors probably vary appreciably among the various insects.

On the other hand, phyiological factors, as well as the genetic characters of the cane variety, doubtless play a major part in the recovery of blighted canes when froghoppers are no longer present. This power of recovery obviously helps to determine the magnitude of the financial loss, and therefore, from the grower's point of view, severity of blight will depend to a certain extent on the metabolic vigour of the plants. This, however, is widely different from the concept that susceptibility to attack hangs on the water balance of the host. This concept is still receiving experimental attention, and much more information is required before its validity can be entertained.

Yours, &c.

ALAN PICKLES,
Chief of Division

THE MONGOOSE.

The present position of the mongoose in the West Indies.

By J. G. Myers.
Imperial Institute of Entomology.

The European black rat (*Epimys rattus*) accompanied the early colonists in the New World and already by 1654 was a serious plague in the French Islands. During the eighteenth century and the early part of the nineteenth it was one of the greatest pests West Indian agriculture has encountered, before or since. In 1789 Browne computed that it often destroyed a quarter or more of the Jamaican cane crop.

Planters and Governments were at their wits' end for a solution—*the bounty system having failed hopelessly*—and the introduction of the mongoose was almost a forlorn hope, the last of a succession of attempts at biological control beginning before 1750.

The introduction of the mongoose into most of the Colonies where it now occurs was made in the seventies and early eighties of the last century. In Jamaica, where the rats were apparently at their worst, it spread and multiplied so quickly, that ten years after the importation it was credited with saving the Colony £45,000 per annum.

In most of the islands, between 10 and 15 years after the introduction of the mongoose, public opinion of it made a complete *volte face*. Rats, though diminished, were still abundant, and the mongoose was said to be destroying many ground-nesting birds, lizards and toads, while its depredations on poultry were wholesale. There was alleged further a great increase in insect pests due to the killing of insectivorous vertebrates by the mongoose.

In Jamaica this phase of public disfavour passed very soon and the mongoose is still considered to do more good than harm. The same opinion prevails in Martinique and St. Lucia where the animal was imported to suppress the fer-de-lance snake (*Bothrops atrox*) once exceedingly common, but now very rare in the former (Barbour, 1930) and uncommon in the latter. In Trinidad, however, and in St. Kitts, Antigua, Barbados and St. Vincent the mongoose is generally considered an unmitigated pest. Bounties for its destruction are, or have been paid by the Governments of all these five islands. The highest price paid is apparently in Trinidad, where one shilling was paid for a time, though it is now reduced to sixpence. Until recently, one of the large estates added an additional sixpence. In 1903 it was even proposed to raise the reward to five shillings. Later it became necessary to pass an ordinance making it illegal to keep mongoose in captivity, for it was feared they were being reared for the bounty.

What then are the facts as to the influence of the mongoose upon West Indian agriculture? It occurs at once to a visitor to compare the incidence of pests in the islands with and those without the mongoose. Unfortunately the exceeding diversity of conditions in all the islands renders the comparison less valuable than it might be. The two chief British islands which have not now and have never had the mongoose (there was an unsuccessful attempt to introduce it into Dominica) are Dominica and Montserrat. The lesser incidence of scale-insects in Dominica than in some neighbouring islands is undoubtedly due to the favouring influence of an excessive rainfall on their fungous parasites. Scale-insects are almost as unimportant in Trinidad and Jamaica, where the mongoose is common. Montserrat differs from its neighbours in insect infestation in no marked degree. If we compare it with St. Vincent the comparison is all in favour of the latter, though the mongoose there is abundant. With regard to rats, there is undoubtedly more damage to cane by these pests in Jamaica than in any other British island. In some parts of Jamaica and on some crops they cause the loss of as much as one-third (*Journ. Jamaica Agric. Soc.*, XXIV, p. 90, 1920). Rats and petty thieves are, in fact, the most important agricultural pests of Jamaica, for the island as compared with Trinidad and the Leeward and Windward Islands, is remarkably free from injurious insects.

There can be little doubt that the earlier phenomenal and widespread outbreaks of the rats in Jamaica were materially reduced by the mongoose, and it is probable that future plagues would be similarly alleviated or even prevented. But under normal conditions and in the other islands it is doubtful whether the mongoose is very efficacious as a rat-destroyer. In Hawaii, where it was introduced from Jamaica in 1883, it "plays a certain definite part as a control factor. Being much less prolific than rodents it does not keep up with them sufficiently to be a "cure-all" for rats, but it helps." (Pemberton, 1925.) About 50 per cent. of 356 pellets examined in Hawaii contained nothing but remains of rats and mice. In the midst of the much richer West Indian fauna the proportion of rats to the total diet is shown by the stomach examinations of Watson, of Urich and of Williams to be incomparably smaller. It is proven also that considerable numbers of insect-eating birds, lizards and toads are eaten, and also large quantities of insects, most of which are injurious. There can be no doubt also that certain ground-nesting birds and a number of the larger ground-lizards and snakes have been either exterminated or more than decimated. The ground-lizards of the genus *Ameiva* which have been shown by Wolcott and others to be valuable insect-eaters, formerly occurred as a distinct species on almost every one of the larger islands. According to a valuable survey made by Barbour

in 1929, these lizards are now extinct on St. Croix, St. Thomas, Nevis, Guadeloupe, St. Lucia and St. Vincent, and practically confined to town limits in St. Kitts and Antigua. In St. Eustatius, Montserrat and Dominica, where the mongoose does not occur, these lizards are still in considerable numbers. Similar facts may be quoted regarding other genera of lizards and snakes.

It has been suggested that the damage done by the mongoose to birds has been offset by its destruction of rats, which ordinarily would destroy many tree-nesting birds beyond the reach of the mongoose. But it has been otherwise pointed out that the latter has made the rats essentially arboreal animals, thus driving them further into the haunts of birds. It may be mentioned, however, that the black rat (*Epimys rattus*), which was introduced into New Zealand in the early days of settlement, eventually became almost wholly arboreal (and is now *the* "bush-rat") there, following on the latter importation of its arch-competitor, the brown rat (*Epimys norvegicus*) which is now the domestic rat. It seems probable to me that the same thing has happened in the West Indies, and would have happened even without the intervention of the mongoose.

To sum up, it may be stated that, agriculturally speaking, the mongoose is undesirable, since, although it has undoubtedly diminished the numbers of poisonous snakes, and has played a certain part in diminishing the more severe plagues of rats, it has exterminated or greatly reduced a number of species of ground-nesting birds and insectivorous lizards and toads, and is, in addition, an important pest of poultry. In the absence of sufficient data on the food-habits of the above birds, lizards and toads, it must, however, be admitted that the effect of the mongoose on the insect pest situation is not definitely known, but has evidently been highly exaggerated.

By far the greatest need in the mongoose situation at present is intensive, quantitative research, not only on the food and biology of the mongoose itself at different seasons and in different localities, but also on the population, distribution and food of the insectivorous birds, lizards and toads which it kills. Research of this kind could well be organised at the Imperial College and would inevitably lead not only to a true evaluation of the mongoose's effect on agriculture, but to an efficient and economical means of control. The bounty system is neither. Bounties have now been paid for mongoose for upwards of 30 years in various colonies, and there is not the slightest evidence that they have had any effect whatever on the mongoose population. It may be confidently asserted that the same sums of money expended on offerings to *Apollo Smintheus*, the god of vermin, would have been just as efficacious. It is urgently suggested that a sum equal to one-half that annually wasted on bounties be invested in intensive research for a period of three years.

THE MONGOOSE IN TRINIDAD.

By F. W. Urich.

The mongoose has been in Trinidad for nearly 60 years and today it is found through the length and breadth of the Island mostly near cultivated and abandoned lands. It is very rare in the forests. Eighteen years ago it had not reached Cedros, Mayaro, Oropuche and La Brea and it was rare at Toco and Blanchisseuse. From the Department of Agriculture's records it appears that carcasses have been sent in recently to 48 different stations representing every Ward of Trinidad. It can now be safely assumed that it is firmly established in this Island. It does not occur in Tobago.

Since Circular No. 12 of the Board of Agriculture on "The Mongoose in Trinidad and Methods of Destroying it" was published in 1914, I made a preliminary examination of the stomach contents of mongoose in 1918, and C. B. Williams continued this investigation, the results of which were published in a valuable article on the food of the mongoose in Trinidad (1918). No further publications have been issued since. Much correspondence has appeared in the newspapers, but no new methods of control suggested.

In regard to methods of control there has always been a feeling that the destruction of mongoose devolved on the Government who started a system of paying for carcasses. In 1902 Mr. McInroy, then Manager of the Government Farm, suggested to the Agricultural Society that a reward of one shilling be paid for each whole carcass, and this was accepted by Government. In 1904 a reward of five shillings for each female was paid. In 1907 frauds were discovered in connection with the payment of the premiums and measures taken to prevent their repetition. At the end of 1908 the premiums were stopped. From 1912 to 1926 no premiums were paid. In 1927 the Board of Agriculture recommended the payment of premiums. This recommendation was adopted by the Government in March, 1927, the sugar planters paying one-third of the total cost. Payments are still going on.

A comparison of the number of carcasses paid for may be of interest. From 1902 to 1908, in 12 Wards of Trinidad 30,895 mongoose were accounted for at a cost of £3,950. From April, 1927 to December, 1930, the figures stand at 142,324 mongoose costing £3,558 for all the Wards of Trinidad. Beyond proving the increase and distribution of the pest this expenditure has had little effect in controlling these animals. (*See* Tables I and II appended overleaf.)

Experiments conducted on Esperanza Sugar Estate showed that from September, 1912 to March, 1914, one man caught 334 mongoose; another man in the Maraval district, from April

to December, 1913, accounted for 348 animals; and another in the Laventille and San Juan districts from June to December, 1913, trapped 112 mongoose. It can be seen from the above how far individual effort could go towards control. In connection with the food of the mongoose Williams' careful work and tabulations of the stomach contents of mongoose still hold good, while his conclusions have not been refuted.

Table I.

Return of Mongoose paid for at 48 Stations in all Wards of Trinidad, kindly supplied by the Department of Agriculture.

	1927.	1928.	1929.	1930.	Totals.
January ..	..	3,987	3,364	3,059	10,410
February ..	..	3,273	5,260	2,730	11,263
March ..	..	5,281	6,929	2,689	14,899
April ..	152	5,214	4,443	3,654	13,463
May ..	9,139	5,170	3,246	3,082	20,637
June ..	4,929	3,356	2,858	2,917	14,060
July ..	4,231	2,504	1,781	1,852	10,368
August ..	1,808	2,391	2,169	1,351	7,719
September ..	2,322	2,410	2,237	1,573	8,542
October ..	3,447	5,269	2,779	1,588	13,083
November ..	3,299	2,480	1,927	1,816	9,522
December ..	2,347	2,183	2,299	1,529	8,358
Totals ..	31,674	43,518	39,292	27,840	142,324

In the dry season January to May, 1928 to 1930, 61,381 mongoose were paid for, and in the wet season, June to December, for the same years, 49,279.

Table II.

Return of Mongoose destroyed from April, 1902 to February, 1908 (From Proceedings of the Agricultural Society of Trinidad and Tobago, Vol. XIII, page 131.)

Ward.	*Number.*	*Cost.* £	s.	d.
Savana Grande ..	74	7	4	6
Manzanilla	541	54	15	3
St. Ann's and Diego Martin	3,143	395	7	6
Tacarigua	13,925	1,851	14	0
Cedros	Nil.			
Mayaro	Nil.			
Couva and Chaguanas ...	8,200	995	0	0
Toco	3		6	0
Montserrat	214	26	9	6
Oropuche and La Brea	Nil.			
Naparima	43	5	7	6
Arima	4,752	614	12	1½
Totals	30,895	£3,950	16	4½

The froghopper pest is attributed chiefly to the mongoose which plays only a limited part in the parasite complex centering round the froghopper.

Changes in Trinidad's Fauna.

Some changes in the fauna of Trinidad due to the introduction of the mongoose and the opening up of new estates may be of interest. The period under review is from 1890 to 1923, during which time I devoted myself to economic zoology and visited most parts of this Island.

Rats.

The rat population of Port-of-Spain has not changed. In the nineties the English black rat, *Mus rattus*, was fairly common near the Wharf but today it is almost extinct, having been replaced by the Alexandrine rat, *Mus alexandrinus*, by interbreeding and destruction. No unusual occurrence of rats was noticed in the cane fields but they are still common about buildings and yards of all estates in Trinidad.

Of the indigenous species *Nectomys palmipes*, a water rat, fairly common on the banks of rivers formerly is now rare. Recently two specimens were found in the stomach of a Fer de Lance snake killed in the upper reaches of the Aripo River. *Oryzomys brevicauda*, a diurnal mouse, is also exceedingly rare; the same holds good of the pouched rat *Heteromys anomalus*. The large eyed cacao rat, a tree inhabiting species, *Rhipidomys couesi* is still a pest in the Nothern Range. The spiny rat, *Loucheres guianae*, which is a pest in Tobago is now rare.

Opossums.

The large and small species of opossum are still common here. The Manicou, *Didelphis karkinophaga* and the Manicou Gros Yeux, *Philander trinitatis* and *Marmosa murina* are still common and destructive to bird life. The Manicou is a well known predator on poultry. Tree boas as well as Fer de Lance exercise a check on Manicou Gros Yeux.

Birds.

As far as my observations go, no species of any bird has been exterminated, on the contrary, some species in and near towns have increased. The Tinamou or Quail, as known locally, is now rare on cocoa estates, but it can always be heard in the forests. Ground doves are still numerous; of the insect eating birds the Anis (*Crotophaga ani*) are not as common as formerly, but they are far from being extinct. Most of the tree nesting birds seem to suffer but little; fly catchers are sometimes taken by mongoose when they swoop down too low after an insect. Thrushes are exposed when feeding on the ground. During the dry season all birds are exposed to mongoose attack when in search of water which at that time becomes very scarce in some districts.

Lizards.

Ground Lizards, *Ameiva surinamensis* are not as common as formerly. They have survived in the vicinity of towns, villages and country houses where their greatest enemy is not

the mongoose but the domestic cat. In 1917 the Manager of the Waterloo Estates wanted to establish ground lizards in the cane fields and obtained from the vicinity of Port-of-Spain between the months of May and October, 1917, 4,157 individuals (Table III). The experiment was, however, a failure, no doubt due to mongoose. Small species of lizards belonging to the *Geckonidae* and *Iguanidae* are still plentiful. The "Matte," *Tupinambis nigro-punctatus* seems to be extinct or very rare. The slippery back lizards, *Mabuya aurata* and *M. agilis* are now very rare, if not extinct. Representatives of the genus *Cnemidophorus* (medium sized ground lizards) are rare on the main Island but common on the Bocas Islands where there are no mongoose.

Table III.

Lizards caught in 1917 in the vicinity of Port-of-Spain.

21st May,	1917	161
22nd May,	1917	176
2nd June,	1917	652
6th and 7th June,	1917	313
14th June,	1917	270
22nd June,	1917	167
29th June,	1917	236
6th July,	1917	86
13th July,	1917	160
20th July,	1917	123
27th July,	1917	124
3rd August,	1917	161
10th August,	1917	143
5th October,	1917	324
11th October,	1917	340
18th October,	1917	310
25th October,	1917	411
		4,157

Snakes.

Many of the small ground inhabiting snakes are rare. *Drymobius boddaerti* was common in 1890 but now is exceedingly rare on the main Island but very common on the Bocas Islands. The following snakes which were fairly common in the country are very rare nowadays :—

Phrynonax 3 *species, Spilotes pullatus, Coluber corais* and *Oxyrhopus coronatus*. The slug eating snake *Petalognathus nebulatus* is still common in gardens out of town. The Boas seem to have held their own. *Corallus cookii*, the tree boa is fairly common and *Boa constrictor* or *Macajuel*, seems to be on the increase. Mongoose have been found in the stomachs of full grown specimens of this snake. I have every reason to believe that this snake can exercise valuable control on the increase of mongoose. It should be protected. Our poisonous snakes, the two species of Corals and the two pit vipers—*Bothrops mutus* and *B. atrox* have not been affected in any way as they are essentially forest inhabitants.

Frogs and Toads.

Tree frogs have of course not suffered at all. The species of toads and frogs inhabiting the damp forests have not been affected in the least by the mongoose. There is a decrease of *Bufo marinis*, the common large toad as well as members of the genus *Leptodactylus* on sugar estates, but they have not been exterminated.

Summary.

The mongoose must be considered as a serious agricultural pest to be placed in the same class as rats and squirrels. It is not however as serious as parasol ants, cacao beetles and froghoppers.

It is unlikely that it will ever be controlled by the payment of premiums and it may well be left to be dealt with by individual effort.

Special research on the food and habits of the mongoose might be conducted and special campaigns organised to help planters towards better and co-operative control.

Bibliography.

(1) 1914. F. W. Urich. The Mongoose in Trinidad and Methods of Destroying it. *Circular* 12. Board of Agriculture.

(2) 1918. C. B. Williams. Food of the Mongoose in Trinidad. *Bull. Dept. of Agric., Trinidad*, Vol. XVII, pages 167-186, 1918.

(3) 1918. Rats and Mongoose in the West Indies, Reprint from *Agric. News in Bull. Dept. of Agric., Trinidad*, Vol. XVII, pages 187-190.

(4) 1918. W. G. Freeman. The Mongoose. *Bull. Dept. of Agric., Trinidad*, Vol. XVII, page 166.

(5) 1918. The Mongoose Ordinance. *Bull. Dept. of Agric.*, Vol. *Trinidad*, XVII, pages 190-192.

(6) 1921. C. B. Williams. Report on the Froghopper Blight of Sugar-Cane in Trinidad, pages 87-90.

(7) 1930. Thomas Barbour. Some Faunistic changes in the Lesser Antilles. *Proceedings of the New England Zoological Club*. Vol. XI, pages 73-85.

COLONIAL APPOINTMENTS.

The following appointments and transfer have been made by the Secretary of State for the Colonies during January, 1931 :—

Mr. N. D. Simpson, Systematic Botanist, Agricultural Department, Ceylon.

Mr. J. B. Ashmore, Inspector of Plants and Produce, Gold Coast.

Mr. R. J. W. Grimm, Inspector of Plants and Produce, Gold Coast.

Mr. E. L. Hay, Inspector of Plants and Produce, Gold Coast.

Mr. A. Quist, Inspector of Plants and Produce, Gold Coast.

Mr. W. Watson, Inspector of Plants and Produce, Gold Coast.

Mr. H. Wolfe (Deputy Director of Agriculture, Tanganyika), Deputy Director of Agriculture (Plant Industry), Kenya.

BIOLOGICAL CONTROL.

I. Insect Pests.

By A. D. Imms, D.Sc., F.R.S.
Rothamsted Experimental Station, Harpenden.

Biological control, in the strict meaning of the term, embraces all agencies of a biological nature that exercise a restraining or controlling influence upon the multiplication of other forms of life. It represents, therefore, the sum total of the activities of bacterial, fungal and other diseases: of insectivorous birds and mammals: and of parasites and predators. In so far as the present article is concerned, reference is confined to the practical utilization of various species of beneficial insects, since it is in this connection that the greatest successes have been achieved.

The control of insect pests by biological methods has made rapid advances during recent years and there is now a bulky and increasing literature on the subject. It will be convenient to discuss these methods firstly with reference to the introduction of specific parasites, or predators, into countries where they did not previously exist: and secondly with regard to the utilization of indigenous parasites.*

Parasite Introductions.—Up to the present biological control has yielded the most satisfactory results in cases where injurious insects have become established in lands they did not previously inhabit, and have there developed into serious pests. In cases of this kind the noxious species have been free from the attacks of these parasites which restrain them in their lands of origin. Biological control, therefore, aims at restoring a condition of natural equilibrium by the introduction of the missing parasite factor. It has to be remembered that introduced pests include some of the worst of the world's insect enemies of food supplies. The more trade is fostered between one country and another the greater are the chances of the spread of pests into fresh territories. Quarantine measures serve to delay and restrain such transfers taking place but, sooner or later, one or other pest manages to run the gauntlet and establish itself in lands thus protected. Artificial measures of control have, in many cases, proved impracticable and their application has involved expenditure of large sums of money to no real advantage. Biological control has consequently been resorted to as a sounder and, in the end, a less expensive measure. Every year brings fresh records of promising results achieved by its application, but it cannot be regarded as a universal panacea as the misinformed are too prone to view it. Each case requires the experience of skilled entomologists and has to be exhaustively considered on its merits. Biological control has had its failures and it cannot be assumed, as the growers did, at one time, in California, that all that is required is to obtain the natural parasites of a given pest and subjugation of the latter will follow.

Insular Conditions.—Up to the present time some of the most successful and complete examples of the biological method of pest control have come about when parasite introductions have taken place under insular conditions. There is the classical case of the Hawaiian Islands where biological methods have proved so successful that insecticides rarely form part of any control measure. Practically all the major pests of sugar-cane have been subjugated in this way. These include the cane leaf-hopper (*Perkinsiella saccharicida*), the Lamellicorn beetle (*Anomala orientalis*) and the cane borer weevil (*Rhabdocnemis obscura*). In the last mentioned example the control in certain localities is less complete and search for further parasites is being undertaken. To this list we have to add the successful control of the cottony cushion scale (*Icerya purchasi*), the avocado mealy-bug (*Pseudococcus nipae*), the cottony mealy bug (*Pseudococcus filamentosus*) and army worms. This is a most encouraging record yet it by no means includes all the successes achieved. Of the failures probably the most significant is in connection with the Mediterranean fruit fly: yet, in this case it is more properly regarded as a partial success than a real failure.

In Mauritius we find that the biological control of sugar-cane pests has also come to the fore. Among the most destructive enemies are larvae of several species of Lamellicorn beetles. One of these, *Oryctes tarandus*, is indigenous to the island and is now largely kept under control by the solitary wasp *Scolia oryctophaga* which was introduced from Madagascar in 1917. With another species, *Phytalus smithi*, which got accidentally introduced from Barbados, less complete control has been attained. The chief insect enemy of this beetle in Barbados is the solitary wasp *Tiphia paralella*. In 1914 the wasp was imported into Mauritius where it has since become established. Although the *Phytalus* has not so far been checked to the degree hoped for the *Tiphia* occasions considerable mortality. There is reason to believe that this parasite has not yet attained its full biological ascendency, and that it will gradually exercise more complete control in future years. In the meantime, however, other methods of repression are still necessitated.

In New Zealand biological methods have resulted in a satisfactory control being achieved over the woolly aphis by the introduction of the Chalcid *Aphelinus mali* from the United States in 1921. The heavy expense, entailed by repeated spraying of the orchards against this pest, has been very much reduced in consequence, with a resulting wider margin of profit in the pockets of the growers. Control of the blue gum scale (*Eriococcus coriaceus*), by the introduction of the ladybird *Rhizobius ventralis* from Australia, has been a complete success and the future control of

* As a convenience the word *parasite* is used in this article in a sense which often implies both parasites and predators.

the Oak Scale by biological means is stated to be well on the way towards being achieved. At the present time biological control is being applied with reference to a number of other pests which have found their way into New Zealand. In some cases the imported parasites have already become established, and the next few years should yield important results relative to the progress of these experiments.

The most recent example of the success of biological methods comes from Fiji. The event has been celebrated by the appearance of a sumptuous monograph in 1930, wherein the whole campaign is recorded in detail. It is concerned with the repression of the coconut moth *Levuana iridescens*, whose larvae, by destroying the palm foliage, threatened the copra industry of the islands with disaster. Since the *Levuana* proved to be free from natural parasites this fact suggested that its original home may be in some land other than Fiji. Search among the Pacific islands failed to reveal the incidence of this moth in any other locality so all hope of discovering its specific parasites had to be abandoned. Recourse, therefore, was made to allied coconut pests and the species, *Artona catoxantha*, was found to be subject to parasitism in Malaysia. On account of the close affinities of the two moths in question it appeared probable that *Artona* parasites would find in the *Levuana* an acceptable host. The campaign hinged on this possibility and after considerable difficulties the Tachinid parasite *Ptychomyia remota* was introduced from Malaysia into Fiji. The success of the experiment was remarkable: six months after its introduction the Tachinid fly had spread throughout the areas of Fiji affected by the *Levuana*. More than three years have now elapsed and the pest has remained under control, while the copra industry has undergone revival.

The successes just recounted appear to be largely due to a combination of favourable circumstances that feature more particularly in many, although by no means all, islandic areas. Under such conditions the native fauna is generally of a peculiar and restricted kind which has evolved as the result of long isolation. The indigenous parasite element in such faunas is often comparatively poorly developed and consequently introduced parasites meet with comparatively few enemies. In other words, they are able to establish themselves readily owing to the absence of any severe competition of a biological character. Furthermore, such islands have a warm equable climate which allows of the multiplication of parasites to go on unchecked by seasonal factors. Also, it has to be remembered that the area to be covered by introduced parasites is more or less circumscribed, particularly so in the smaller islands.

Continental Conditions.—Up to the present the most marked successes obtained on continental areas are with reference to more or less restricted territories, enjoying a warm and tolerably equable climate, and where the affected crops are not wide-spread. The early successes attending the importation of *Vedalia cardinalis* which preys upon the cottony cushion scale (*Icerya purchasi*) of citrus fruits are well known. This predator has subjugated its host in almost every country where it has been introduced. Local successes of this kind have been achieved in California, Florida, South Africa, Portugal, Syria, Egypt and the South of France. In California, also, the introduction of the beetle *Cryptolaemus montrouzieri* from Australia for purposes of controlling the citrophilous mealy bug (*Pseudococcus gahani*) has proved a far less expensive measure than spraying. Although the *Cryptolaemus* is unable to maintain itself from year to year, it can be induced to dominate the citrophilous mealybug if it be continuously bred and liberated in large numbers. There are now a number of local establishments, or insectaries, through the citrus fruit area of Southern California that are given over to the propagation and distribution of the *Cryptolaemus*. The latter is a most efficient predator and speedily cleans infested groves. On the other hand, the host mealybug continues to extend its range, with the result that the breeding and liberation of the *Cryptolaemus* has had to be extended and intensified. Believing that the efficiency of biological control would be strengthened if additional enemies, more especially internal Hymenopterous parasites, were available efforts have been made to locate the country of origin of the pest. In 1916 and 1917 Clausen explored a number of countries in the far East without success. Further search was also made by F. Silvestri, on behalf of the Californian growers, in the Orient without discovering the parasite In 1927 the citrophilous mealybug was found by Compere in Australia which appears to be its natural home. Here it was found to be kept largely under control by natural enemies of various kinds and a number of the latter have now been shipped to California and are already safely colonised in some of the orchards. The next few years will reveal the results of those experiments and whether the degree of subjugation called for becomes achieved. There are other serious Coccid enemies of citrus fruits that have found their way into California, and whose repression forms part of an active programme of biological control today. Thus, the Chalcid *Leptomastidia abnormis* introduced originally from Sicily plays an appreciable part in the reduction of *Pseudococcus citri*. A serious enemy in the form of the black scale (*Saissetia oleae*) is causing great trouble today, and its control by biological means is one of the main projects of the Citrus Experiment Station at Riverside. Various introduced enemies obtained in South Africa have brought about a certain measure of control, but energetic measures are in progress with a view to augmenting their activities by the discovery of other parasites. The red scale (*Chrysomphalus aurantii*) and the purple scale (*Lepidosaphes beckii*) likewise have not so far been subjected to satisfactory biological control.

Passing now from citrus pests, the woolly aphis of the apple is one that troubles growers all over the world. Of recent years much attention has been devoted to the Chalcid parasite *Aphelinus mali* indigenous to North America. Reference has already been made to the successful introduction of this parasite into New Zealand. Its importation and liberation has also taken place in various continental areas: in many European countries it has so far proved of comparatively little value. In parts of Italy, however, it destroys its host at all seasons of the year and is proving an efficient parasite. In South America, especially in the Argentine, it has become particularly efficient, and is also giving promising results in parts of Australia. In South Africa it was at first a failure, but its re-introduction has been successful in certain localities.

Mention must also be made of the losses occasioned to the silk industry in Italy by the imported scale-insect *Diaspis pentagona*, which destroyed the mulberry. In 1891 the pest assumed such serious proportions that the Italian Government passed a legislative measure compelling mulberry cultivators to make strenuous efforts to cope with it. No satisfactory control was obtained, however, until the Chalcid parasite *Prospaltella berlesei* was introduced and became established. Extensive and widespread liberations of this insect have since led to the subjugation of the *Diaspis* over a large part of Italy.

In Canada the enormous damage entailed by the European larch saw-fly (*Lygaeonematus erichsoni*) to forests led to the introduction during 1912-13 of its Ichneumon parasite *Mesoleius tenthrendinis* from England. This parasite has steadily increased in efficiency and in 1927 was found in some localities to be destroying as much as 88 per cent. of its hosts. It is now well established locally in South Manitoba where there appears to be no doubt that it has greatly reduced the prevalence of the saw-fly and its distribution among the forests of Eastern Canada is now being undertaken.

The successful introduction of the larch saw-fly parasite is one of especial interest and importance for the reason that the insect is subjected to the extremely cold winter conditions. For many years strenuous efforts have been made to control the gipsy and brown-tail moths in North America by biological means. Enormous numbers of parasites have been bred out and liberated and, in so far as the brown-tail moth is concerned, there is every indication that a tolerably successful degree of control has supervened. In 1924 the gipsy moth infestation reached its lowest level for twenty years and, in this connection, it is noteworthy that in the previous year the average collective parasitism attained its greatest efficiency. Since then parasitism has declined and a recrudescence of outbreaks of the moth has occurred. The whole problem is complicated by many factors including climatic variations, wilt disease, reduction in planting of favoured hosts, arsenical spraying and the wholesale destruction of the egg-masses. It is, therefore, difficult to evaluate the amount of influence that parasitization exercises. The special parasite laboratory at Melrose Highlands in the meantime continues its work of the mass breeding and liberation of beneficial insects. More recently a number of other immigrant insects have attained a widespread range in the United States and their control by biological means is under weigh at the present time. Among these pests the alfalfa weevil (*Hypera variabilis*), the European corn borer (*Pyrausta nubilalis*), the Japanese beetle (*Popillia japonica*) and the oriental peach moth (*Laspeyresia molesta*) are especially noteworthy. The alfalfa weevil was first reported in America in 1904, while the other pests mentioned are more recent immigrants. In the attempts to control these pests certain species of introduced parasites have become established, but the final outcome of the experiments can only be revealed in years to come. With the corn borer, for example, the greatest chances of success appear to be dependent upon the introduction of a whole range of parasite species, some being adapted to restrain their host in one part of its zone, and others in a different part. It seems unlikely that any one parasite, or group of parasites, will prove equally effective in relation to an insect which has already invaded over 100,000 square miles of territory, where there are notable climatic variations.

Utilization of Indigenous Parasites.—Suggestions have been frequently made, and actual attempts carried out, with a view to making use of indigenous parasites of native pests as agents in the control of the latter. It needs to be recollected that the subject involves somewhat different principles from those concerned with parasite introductions. In the latter case the building up of a condition of natural equilibrium by supplying the missing parasite element is aimed at. The utilisation of indigenous parasites is largely concerned with efforts to modify a condition of equilibrium already highly adjusted. The operations consist either of conserving or increasing the numbers of a parasite or predator in a given area, with the object of obtaining a higher degree of control over an individual species of pest, or of attempting to colonise such parasites in a part of the country where they are scarce or wanting.

Conservation of Parasites. — The principle involved consists of either altering the host parasite ratio by the adoption of methods which allow of more hosts than parasites being destroyed; or, of the abandonment of measures tending to reduce the existing parasite population. Various attempts have been made or advocated in Europe towards these ends but no clearly proved successes have been reported. Such methods are only likely to be successful when carried out by general agreement among cultivators over a wide area; on a small scale only a fraction of the insect population would be affected and no appreciable result likely to supervene. In recent years the method has been put into effect in Louisiana

where the practice of burning the sugar-cane trash is claimed to be an ineffective measure for decreasing infestation by the moth-borer *Diatraea saccharalis*. The trash, it appears, affords shelter to large numbers of hibernating parasites and, following this contention, it was left unburned at the sugar experiment station farm near New Orleans for a period of years, while the State planters as a whole burned their trash. During the years 1915 to 1921 it is stated that the percentage losses due to *Diatraea* were less by three per cent. to 17 per cent. over fields where the trash was left unburned.

Direct Increase of a Parasite Population.—It has been contended that the alteration of the host-parasite ratio in specific cases by the artificial quantitative breeding of suitable parasites is a practical possibility. A species of parasite whose behaviour lends itself favourably to the application of the method is the Chalcid *Trichogramma minutum*. At the present day attention is being concentrated on this species in various parts of the world as a means of controlling the codling moth (*Cydia pomonella*), the sugar-cane borer (*Diatraea saccharalis*) and other moth pests. The *Trichogramma* is a very widely spread parasite of the eggs of such species: many generations a year can be reared in captivity on suitable hosts, and it is claimed that up to one million per day can be bred with comparatively simple standardised technique. Early in the season this parasite is comparatively scarce, while its spread is very slow owing to its limited powers of distribution, but it is maintained that if an intensive infestation can be induced at the right time, potential outbreaks of certain moth pests might be largely counteracted by the wholesale destruction of their eggs by this means. In a recent issue of *Tropical Agriculture* (Vol. VII, pp. 292-295) R. W. E. Tucker has given an account of his experiments in controlling *Diatraea saccharalis* in Barbados by mass liberations of *Trichogramma*. The results so far obtained promise to give satisfactory control of the pest in question. In the meantime good work along similar lines is being carried out against the same pest in Louisiana: against the codling moth in California, and also against the oriental peach moth elsewhere.

Transference of Parasites to new Areas.—Theoretically this method appears to be a feasible one if the absence of a given parasite in a specific area is attributable to causes other than those of a climatic nature. As long ago as about 1872 experiments of this nature were stated to have yielded beneficial results, but it is not possible to discover whether such effects were permanent or not. Quite recently E. H. Hazlehoff has claimed to have achieved promising biological control of the sugar-cane aphid (*Oregma lanigera*) in Java by transferring its native parasite (*Encarsia flavoscutellum*) from established cane fields into newly planted areas. Owing to the practice of crop-rotation, it appears that the aphid establishes itself more readily than the parasite in new cane fields, but the parasite when artificially introduced readily adapts itself and holds its host in check.

L. O. Howard in his *History of Applied Entomology* (1930) instances two very recent experiments of a similar nature. In one case, an experimental reafforestation area in Nebraska was suffering severe losses of its young coniferous trees from larvae of the moth *Rhyacionia frustrana*. The transfer of colonies of an Ichneumon parasite from Virginia, and their liberation in Nebraska, led to an extraordinary change in the situation. In areas where the parasites were liberated as much as 80 per cent. of the hosts were attacked by them, and the percentage of affected trees declined by 60 per cent. In the summer of 1929 there was definite promise that the parasite would be the solution of a very difficult problem. The other case instanced concerns sugar-cane pests in the Island of Negros (Philippines), where W. Dwight Pierce, by redistribution of certain of the indigenous parasite among areas where they were scarce, is stated to have secured a greatly increased destruction of their hosts in such areas. An official report on this work has yet to be published and its appearance will be awaited with considerable interest.

The Outlook for Biological Control.—Biological control aims at bringing about a permanent measure of pest repression. In the most successful cases it may render the application of artificial measures no longer necessary, while in others it may serve to supplement insecticidal or other treatment. It is only in comparatively rare instances, and in a very favourable environment, that almost complete suppression of a pest results, while in many cases a successful outcome is regarded as having been achieved once an appreciable degree of permanent control over a given pest has come about. The subject has shown itself to be infinitely more complicated than it was believed to be about 20 years ago and a great deal of work has been carried out.

The general result of accumulated experience all tends to support the essential soundness of its basic principles. Every project, however, must be considered on its own merits and has to be regarded as an experiment whose final practical outcome cannot be forecasted with certainty. The operations of biological control have often failed through ill-advised or wrong procedures and it cannot be too strongly emphasised that they require expert knowledge, special equipment and special methods. Technical knowledge of the behaviour of specific parasites in relation to their hosts is essential: it enables the most suitable parasites to be selected and the chances of failure, with the consequent waste of both energy and money, to be reduced as far as possible. Experience in the handling and transfer of delicate living insects over, perhaps, many thousands of miles of land and water is also called for. At the destinations of these living cargoes familiarity

with the technique of breeding and liberating parasites, under favourable conditions, is of the utmost importance, or the efforts expended on their discovery and transmission will be discounted.

It has been pointed out, earlier in this article, that some of the most pronounced successes in biological control have resulted in its application under insular conditions. The remarkable work carried out in the Hawaiian Islands is partially due to the special combination of favourable conditions present in oceanic islands of this type, but every credit must be given to the insight and sound knowledge that prompted such schemes and brought so many to a successful conclusion. Probably all oceanic islands afford a more or less favourable environment for the prosecution of similar methods. Many islands of the continental type, as exemplified by New Zealand, Ceylon, the West Indies and others, appear also to lend themselves favourably to such experiments. In a few years time we shall learn much with regard to the various biological control projects now under weigh in New Zealand and the experience so gained will be of the utmost value.

Over continental areas it has already been pointed out that certain localised conditions appear to be more favourable than others. California, bounded partly by the Pacific Ocean and partly by barriers of mountains and desert, is isolated physiographically to an exceptional degree. Conditions more or less analogous to those obtaining in this State prevail in other parts of the world. Thus, in Australia as R. J. Tillyard has observed, there are large areas bounded by mountains or by desert that are ecologically almost comparable with islands. Looked at from this point of view Western Australia, the elevated apple lands of South Queensland and other parts, should afford favourable conditions for the application of biological methods of pest control. Egypt, limited as it is by desert and sea, Mesopotamia, Palestine, Syria and other lands likewise appear to be favourable for parasite introductions.

The biological control of pests menacing crops widely distributed over vast continental areas, where there are pronounced seasonal changes including hard winters, and a great variety of other ecological conditions, has to contend with manifold difficulties. The establishment and spread of an effective parasite population, over such areas, can scarcely result until after the elapse of a number of years. We have, as yet, no proof that parasites alone will attain sufficient control and it remains to be seen whether artificial means will, or will not, be still necessitated as supplementary aids. The possibilities of utilizing indigenous parasites need much more thorough exploration than has yet been accorded to them. There is no promise that this method will become of general application but, so far as can be foretold, it is likely that it may prove efficacious under especially favourable conditions. Finally, the international transfer of the most valuable types of parasites between one country and another is a possibility held for the future. We may say in conclusion that, given due consideration of the factors so briefly outlined, the outlook for biological control is one full of promise. This also is borne out by the increasing number of examples of its application that are being put into being in countries practically all over the world. For a full discussion of the technique, and underlying principles of biological control, the reader cannot do better than digest the recent Bulletin by W. R. Thompson entitled *The Biological Control of Insect and Plant Pests*, published by the Empire Marketing Board, London, 1930, price 1s. net.

COCOA IN 1930.

PRODUCTION has maintained its upward trend. A somewhat severe drop in American consumption during 1930, especially during the latter months, forced down prices to a considerable extent. Fair fermented Accra, f.o.b., opened at 39*s.* 3*d.* per cwt., and, after remaining fairly steady for a month or so, the price gradually gave way until 24*s.* per cwt. was touched in the autumn, while spot Accra, f.f., declined from 44*s.* to 29*s.* per cwt. The fall in the value of the commodity caused Gold Coast native producers to store the beans pending an improvement in price. Harvesting of the new main crop began in October, and only about 26,280 tons had been shipped up to the end of November. The crop is estimated at about 200,000 tons, and, as two-thirds is said to have been gathered, there must be between 90,000 tons and 100,000 tons stored up country. This policy made business exceedingly difficult, but, largely as a result of it, quotations were 2*s.* per cwt. above the lowest at the close of the year. Other descriptions fell in sympathy with the general movement of the market. Trinidad, good to fine, on the spot London, opened at from 62*s.* to 65*s.*, and finished at from 48*s.* to 52*s.* per cwt., while fine Ceylon closed at 77*s.* 6*d.*, after opening at 95*s.* per cwt.

World production for the year is estimated at 547,000 tons, against 537,500 tons in 1929. Of this quantity the Gold Coast produced about 260,000 tons, against 236,000 tons a year ago, and Africa as a whole about 359,000 tons, compared with 353,000 tons in 1929. Countries outside Africa contributed about 188,000 tons, which is about equal to that of the previous year. World consumption is down by about 70,000 tons as compared with 1929. This drop is almost entirely due to the decline in the quantity taken by America, from 224,000 tons in 1929 to 165,000 tons in 1930. The European total, at 284,000 tons, is only slightly below the previous year's level. Germany took 75,000 tons, against 77,000 tons, Great Britain 56,000 tons, against 58,000 tons, Holland 50,000 tons, against 49,000 tons, and France 34,000 tons, against 35,000 tons. At the close of the year, the industry was handicapped by heavy visible supplies.—(*The Times Annual Financial and Commercial Review.*)

WEST INDIAN NOTES.

Compiled by the Advisory Department of the Imperial College of Tropical Agriculture.

Credit Societies and Land Settlement.

Mr. C. Y. Shephard, Professor of Economics at the College, recently visited St. Vincent and St. Lucia at the request of the Governments concerned. In St. Vincent he examined the system of agricultural credit societies and made suggestions for re-organising the societies on a more satisfactory basis. The prime requirement is the appointment of a trained and experienced officer to take administrative charge of the movement and to advise the individual societies. It was emphasised that the officers of the Agricultural Department should not be concerned with the actual payment or collection of monies, but it was urged that agricultural officers should make greater use of the societies for educating the peasants in agricultural matters. In certain circumstances it may become necessary for Government to advance loans to the societies. The sphere of operations of each society should be confined to a village or compact settlement area in which the members are brought into intimate contact with one another, and the total membership should not exceed, say, fifty. Professor Shephard made a very useful suggestion in insisting that loans should be granted for specific agricultural operations, and not, as hitherto, for general agricultural purposes. Before considering the application, and again during the life of the loan, the applicant's holding should be examined by members of the society appointed for that purpose. Any application for loans by the society as a whole should be signed by all the members of the society. In conclusion Professor Shephard strongly recommended as a definite policy that further land settlement schemes should be undertaken by Government whenever the opportunity presented itself and pointed out that nothing had been done in this direction since 1914.

In St. Lucia Professor Shephard investigated the desirability and possibility of conducting a housing and land settlement scheme. Proposals had previously been framed by the Agricultural and Commercial Society of St. Lucia and advice was sought on their soundness. Owing to the decline in the coaling trade and the severe depression in the staple agricultural industries it is generally recognised that some form of land settlement is highly desirable. The new road system will provide access to large areas of undeveloped land, and the funds which have been made available for establishing a government central packing shed, coupled with the improved shipping facilities provided by the Canadian National Steamships, all tend to enhance the possibility and desirability of a land settlement scheme. Professor Shephard's proposals are now receiving the consideration of the St. Lucia Government.

Conference on the Marketing of Fruit and Vegetables.

A Conference was held at the instigation of the Governor of the Windward Islands in St. Lucia to consider problems connected with the marketing of fruit and vegetables in Northern markets, Bermuda and Canada, and to make recommendations in connection with these matters. The Commissioner of Agriculture presided over this Conference and there were representatives from Dominica and St. Vincent, in addition to those from St. Lucia.

Resolutions were passed which included the need for co-operation and uniformity to the greatest possible extent in varieties, in the quality of products, and the type and quality of packages and kinds of containers. Definite recommendations were made as to the desirable types of containers for the principal products with correct measurements for each type. A label design was considered which it was hoped would in due course be adopted by all the Conference Colonies.

The question of appointing joint agents to whom fruit and vegetables might be shipped, was also discussed, and agreed to.

Government inspection of fruit and vegetables, and the legislation in vogue in each colony controlling the same were considered and uniformity recommended as far as possible.

An important step was taken when the Conference recommended that freedom of sales by individual shippers should not be interfered with. All recommendations for co-operation and concerted action referred to the Government Agencies, such as the Departments of Agriculture, the Fruit and Vegetable Bureaux and the Marketing Agents in the Conference Colonies. The hope was expressed that other Colonies and Presidencies and individual shippers would come into line in the matter of uniformity of packages and labels and in the matter of purchasing supplies.

The subject of canning and preserving was considered and it was suggested that a Central Canning Plant might be set up at St. Lucia while the possibility of obtaining the loan of a plant from the Welsh Tinplate Manufacturers was mentioned.

The Conference recommended the creation of a Central Marketing Organization with a Marketing Officer in charge. The Marketing Officer would combine the duties of travelling fruit inspector with that of manager of an agency for the purchase of supplies for all the Conference Colonies. It is essential for further development on sound lines that the inspectors and packers in each island adopt a single standard of grading, and it is most important that this standard should be set as soon as possible. An experienced officer moving from place to place instructing and demonstrating would provide the surest means of attaining to this single standard. The travelling inspector would, also, be in charge of the Central Marketing Agency which would purchase supplies, crates,

labels and all other supplies including fertilizers and tools, for all the marketing agencies on a co-operative basis. This Central Agency would also be the centre for collecting and distributing information relating to markets, prices, supply and demand.

The appointment of a Marketing Officer and the establishment of a Central Agency are the most important needs of the fruit trade at the present time.

* * *

The Fruit and Vegetable Trade.

During the first three months of the year, the volume of business in the vegetable industry with Canada is at its height. Unfortunately the severe drought experienced in Antigua, Nevis, and St. Kitts, and to a lesser extent in Montserrat, has checked development. In each Island arrangements have been made by government to cope with large quantities, but it is only in Montserrat that the packing houses were really kept busy. Small shipments were sent to Canada from all these islands, and in addition from St. Vincent and Grenada. In the case of Montserrat as many as 4,500 boxes have been dispatched in one shipment, and the total for the season has now reached over 13,000 boxes. The bulk of the shipments have been tomatoes, but small trial shipments of string beans, egg plants, and cucumbers were also made.

The Assistant Commissioner of Agriculture attended the annual meeting of the Eastern Canada Fruit and Vegetable Jobbers' Association held in St. John, N.B. January, 1931. This association has a membership of 92 and its members handle 90 per cent. of the fruit and vegetable trade of Canada. The Director of Agriculture from Bermuda was also a delegate. Papers were read by both these delegates on, "The West Indies as a source of Canada's fruits and vegetable requirements." There was also staged in the Hall adjoining the Conference room a small exhibit of the fruit and vegetable products of the Bahamas, Bermuda, and the West Indies. In this way, and by articles in the Press a considerable amount of publicity was given to West Indian products.

At the conclusion of the Convention, Mr. G. A. Jones inspected consignments of fruit and vegetables arriving from the Bahamas at Halifax, and from the West Indies at St. John, N.B. and later saw these consignments being handled at the docks and forwarded to their destination. Notes have been submitted to the officers in charge of the various fruit depots, on the condition of the consignments on arrival in Canada and suggestions put forward as to how the grading and packing might be improved.

Mr. Jones also visited a number of fruit and vegetable brokers, jobbers, wholesalers and retailers in Montreal, Ottawa, St. John, Halifax and Bermuda, and inspected the West Indian produce which was being handled by the various organizations. The views of the trade were canvassed as to the quality of the fruit and vegetables now arriving from the West Indies, and the mode of their preparation, grading, packing, and packages, &c. There is considerable lack of uniformity between the various islands in these matters and the need for action on the lines outlined in the report of the St. Lucia Conference is very apparent. Above all there is need for the appointment of a marketing officer who will co-ordinate the work of the marketing depots in each island.

During his stay in Ottawa, the Assistant Commissioner established contact with the officers of the various divisions of the Federal Department of Agriculture and obtained much useful information.

* * *

Insect Pests.

The common sweet potato weevil in the Lesser Antilles is the well known Jacobo and Scarabae (*Euscepes batatae*). Although the insect occurs throughout the West Indies and South America, its presence has only recently been recorded in Trinidad. The weevil, *Cylas formicarius*, which has been such a serious pest of sweet potatoes in the Southern States has recently been reported with the specimens from St. Kitts. Both these insects have a wide distribution but until now Cylas has not been known in the Lesser Antilles. This insect has been reported as having been intercepted by the quarantine service at American ports from Barbados and St. Lucia ; but as there is no record of the occurrence of Cylas in these islands it is concluded that the reports may have been due to a mistake in identification.

The pink boll worm and cotton stainers have not caused any serious losses to the cotton crops in the season just passed. The cotton worm has appeared in sporadic attacks. In Carriacou the leaf blister mite was found by Mr. Evelyn on his recent visit to be abundant on Maria Galante cotton, while another perennial cotton called locally "silk" or "fine", cotton appeared to be quite immune to its attacks.

The rapid increase in the areas of tomatoes in these islands will probably be followed by the appearance of pests and diseases. The tomato flower midge or bud maggot (*Contarinia Lycopersici*) which was described from St. Vincent in 1911 is reported as attacking tomatoes in Trinidad and observations are being made on the nature and extent of the injury. The following note taken from the Report of the Agricultural Department of St. Vincent 1910-11 describes an attack by this insect.

Tomato Bud Maggot.—Early in May, considerable difficulty was experienced in obtaining fruits of tomatoes. The plants did not show greater distress than usual from the numerous local fungus pests. Examination revealed the flower buds to be turning yellow and falling off. Yellow buds contained minute grubs or larvae feeding on the reproductive organs, stamens and pistils. These larvae arose from eggs deposited, in the early evening, in the buds while these are not larger than the head of a medium-sized pin.

CITRUS PROPAGATION.

FIG. 1.—*General view of the two Solar Propagators. The one first constructed is on the left. The slightly different proportions will be noted. Drainage holes at ground level and holes in the propagating chamber, for the insertion of thermometers, are plainly visible.*

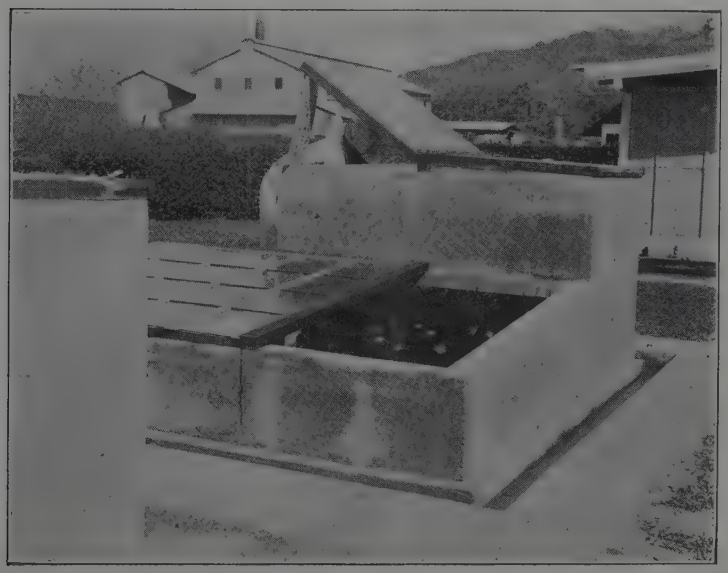


FIG. 2.—*Closer view of the second Propagator. The glass sash of the Heating Chamber is partly removed to show the black water-filled bottles inside.*

CITRUS PROPAGATION.

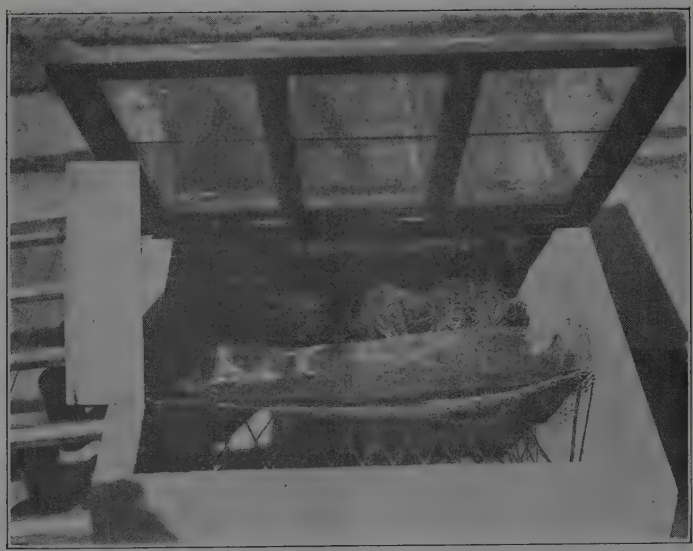


FIG. 3.—*Looking into the Propagator before the sand for the rooting bed was put in. The method of supporting the sand can be clearly seen. It is supported upon coconut fibre, wire gauze, wire netting, and expanded metal. Gauze and wire netting were rolled back to show the expanded metal.*

FIG. 4.—*Cuttings set in the Propagator for rooting test.*

FIG. 5.—*Two rooted cuttings of West Indian Lime. The photograph was taken after the cuttings had been set for 22 days. The cuttings are branches six to seven inches long, and the longest root is about three and a half inches in length.*

Five or six, or more larvae may inhabit a single bud. Occasionally the damage is not sufficiently great to cause the bud to fall; it may even expand and show the gnawed, blackened stamens and pistil, though it is exceptional to find such damaged flowers developing into fruits. The larvae leave the buds when full grown and pupate in the soil.

* * *

Sea Island Cotton.

THE cotton situation is still grave in all the islands interested in the crop. The market is practically dead, and the surplus unsold. Stocks appear to be increasing rather than decreasing. The 1930 crop from Montserrat created a new record, and in St. Kitts a good crop was reaped. The current crops (1930-31) in St. Vincent and Barbados are reported to be good; that of St. Vincent, showing an increase in acreage and in yield per acre, is a further indication that the change of planting season has been a beneficial one. The severe drought is reported to have affected seriously the Nevis crop, which it is feared will be almost a complete failure. The cotton growers of St. Kitts and Montserrat in the planting season which has now opened will probably make very substantial reductions in the areas to be planted. In Barbados, St. Vincent and Nevis, where the planting season begins in September and October, similar reductions in areas will probably be made.

Co-operation between all growers of sea island cotton in the British West Indies could be made to affect the production and the price, and this is the only crop which the West Indian agriculturists can control in this way. The West Indies are producing about as much sea island cotton as the spinners are using each year. If all the cotton growing islands would combine to reduce production it might be possible for accumulated surplus stocks to be used up and to improve the market.

With the depression in the sugar industry, and the need for reducing the output of cotton the difficulty of employment of agricultural labourers becomes more and more insistent. The great need will be for increases in the production of provisions for local use. A settled peasantry can feed itself by growing its own food. If land were available, labourers who have money and time might be provided with allotments in which to grow their own food crops, and much distress might thus be averted.

* * *

Agricultural Shows.

Agricultural shows have recently been held in some of the islands. The Agricultural Exhibition at Barbados is an annual event held in December. This is an established and recognized function which undoubtedly plays an important part in the agricultural life of the colony. In Trinidad a successful Exhibition has just been held after an interval of two years. Previous to 1929 no Agricultural show had been held since 1912, except in 1919. In St. Vincent the Agricultural Exhibition held on 7th December, 1930, was the first of its kind in 25 years. In St. Lucia and Antigua exhibitions were held in February, 1930, and in Dominica a successful show was held in March last year after an interval of 23 years. These Agricultural and Industrial Exhibitions are very useful, and if held every year, or at least at short intervals, they are more likely to improve than if they take place at only long intervals.

* * *

Miscellaneous Information.

At the urgent request of the Governor of the Windward Islands and with the permission of the Commissioner of Agriculture, Mr. S. H. Evelyn, Cotton Research Officer stationed at St. Vincent paid a visit to Carriacou, a dependency of Grenada, to report on the cotton industry in that Island, and to make recommendations for its improvement. Mr. Evelyn has presented a very useful report and has made certain recommendations which, if adopted, should go a long way towards improving the quality of the cotton now grown. The cotton grown in Carriacou is a perennial cotton, known as Maria Galante. It appears at present, however, that the stock is very mixed.

Mr. F. A. Simmons, foreman of the Agricultural Department of St. Vincent, was appointed Agricultural Instructor acting in Carriacou last year.

Mr. E. O. R. Lake was appointed Agricultural Instructor for the Island of Anguilla for a period of three years, and assumed his duties on 1st January, 1930. Mr. Lake, was educated at the Antigua grammar school, and after four years war service has been engaged as an overseer on sugar estates in Antigua. This appointment has been made possible by a free grant from the Colonial Development fund.

Mr. E. S. A. Chin who is a holder of the Diploma of the I.C.T.A. has been appointed Agricultural Assistant to the Agricultural Service in the Leeward Islands with duties in Montserrat in the first place. Mr. Chin passed his final examinations last June, and has since then been employed as Field Assistant in the Genetics Department of the Cotton Research Station, Trinidad. Mr. Chin left Trinidad for Montserrat on 9th March, 1931.

Major R. L. Wheeler, Fruit Transportation Specialist of the Department of Agriculture, Ottawa, at the invitation of the Government of Bermuda, visited that Island in February, 1931. It was also arranged for Major Wheeler to visit the Eastern group of the West Indian Islands making a study of the transportation problems with special reference to fruit and vegetables. After calling at each of the Islands from St. Kitts to Trinidad, he remained seven days in Trinidad, and returned to Canada *via* Jamaica. During his stay in Trinidad Major Wheeler spent five days at the College as the guest of the Principal. He interviewed the heads of the various departments interested in problems connected with the development of the fruit and vegetable industry.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Experiments on Imbibition. *N. M. Rydlewski.*

In some mills in Cuba the author found the imbibition water being applied at the entrance of the bagasse to the mills, so some experiments were made with the object of showing whether this method or application as the bagasse is emerging is the more advantageous. Two mill tandems were available, each of the two having the same roll settings, the same hydraulic pressure, the same driving power, and other conditions generally as similar as possible. Hot water was used; but the metres at hand were found unreliable for its measurement, the amount used being therefore calculated from the densities of the normal and diluted juices. Nor was the bagasse weighed, being obtained from cane, plus imbibition water, minus diluted juice. The diluted juice was weighed in Richardson automatic scales, and the density of the normal juice was calculated from that of the crusher juice by means of weekly factors. In the comparison of results, the term "imbibition efficiency" as used by the Fulton Iron Works was included, which figure has been found from many milling tests made in many factors to be a useful one. It is calculated from the formula:

$$\frac{100-(\%\ \text{sucr.}+\%\ \text{water}+\%\ \text{fibre in the bagasse})\times 100}{\text{Brix of the last mill juice}},$$

and a value of about 20 is taken as representing good imbibition work. Bagasse and juice samples were analysed every three hours. Below are some of the results obtained, which represent the average of figures obtained as the result of grinding some 3,500,000 arrobas or 40,000 tons of cane.

According to the author, by the increase of sucrose extracted per cent. sucrose in the cane, and by the better imbibition efficiency (with practically the same quantity of imbibition water) they are clearly in favour of the water being sprayed on the bagasse leaving the mills.

	Entering the Mills. Tandem.		Leaving the Mills. Tandem.	
	No. 1.	No. 2.	No. 1.	No. 2.
Imbibition per cent. cane	13.55	19.89	13.52	15.84
Dilution per cent. cane	11.24	16.68	11.33	13.28
Normal juice extraction per cent. cane ..	82.93	83.87	83.86	83.83
Sucrose extracted per cent. sucrose in cane ..	94.40	94.66	95.22	94.91
Sucrose extracted per cent. cane	9.60	9.76	10.18	9.89
Sucrose lost in bagasse per cent. cane ..	0.57	0.55	0.51	0.53
Sucrose in cane per cent.	10.17	10.31	10.69	10.42
Diluted juice, Brix.	13.02	12.31	13.29	12.78
Do. polarization	10.20	9.71	10.69	10.18
Do. apparent purity	78.34	78.87	80.44	79.65
Last mill, juice Brix.	5.43	5.36	4.64	4.90
Do. polarization	4.02	3.96	3.40	3.63
Do. apparent purity	74.03	73.92	73.42	74.10
Bagasse per cent. sucrose	2.91	2.86	2.81	2.83
Do. moisture	49.28	29.06	49.15	48.80
Do. fibre	46.79	47.07	47.03	47.38
Imbibition efficiency	18.70	18.80	21.70	20.20

—(*The Inter. Sugar Journal*, Vol. XXXIII, No. 385.)

* * *

Cuban Sugar Crop.

The 1930-31 Cuban sugar crop has been officially limited to 3,496,640 short tons (3,122,000 long tons), according to a cabled report to a trade paper. This is a decrease of 33 per cent. or 1,734,850 short tons from last season's production, officially estimated at 5,231,490 short tons.

The 1930-31 crop is to be distributed as follows: After allowing 168,000 short tons for domestic consumption, 2,886,240 short tons are to be assigned for exports to the United States and 442,000 short tons for exports to other countries. In addition to this, 1,456,000 short tons (1,300,000 long tons) of the present stocks are to be segregated and disposed of over a five-year period to destinations outside of the United States at the rate of 291,200 short tons annually. This makes a total of 733,600 short tons (655,000 long tons) sugar available in 1931 for countries other than the United States.

Cuban sugar restrictions are in accordance with the plan as agreed upon at the Berlin sugar conference, at which seven important sugar exporting countries participated. By the final terms of this agreement, the export quota for each country is fixed annually over a period of five years. These countries produce only about 40 per cent. of the world's sugar crop, but they export about 70 per cent. of the sugar entering world trade.—(*Foreign Crops and Markets*, Vol. XXII, No. 7, U.S.A. Dept. of Agriculture.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Furfural.

Furfural is a liquid, chemical reagent which prior to 1922 was obtainable only in small quantities and cost from £2 to £5 a lb. At the present time, it is obtainable in thirty ton lots at the rate of 10 to 17 cents a lb. The great increase in production and decrease in price has been made possible by the discovery that nearly pure furfural can be obtained from any vegetable matter which contains pentosans or pentoses. Waste materials such as corn cobs and oat hulls have sufficient of these constituents to enable furfural to be produced economically. The manufacturing process is simple and inexpensive. It consists in distilling the raw vegetable material in the presence of mineral acid or a suitable catalyst. The distillate contains furfural and water which are separated by fractionation.

Industrially, furfural is used chiefly in the production of artificial resin. Several types of resin, each with distinctive and valuable properties, can be produced by varying the treatment of the furfural. Thus, if furfural is mixed with aluminium chloride and treated to 100°C. for several hours, a jelly-like mass, fusible and soluble in acetone, is obtained. Continuation of the reaction or further heating renders the mass infusible and insoluble. Interaction of furfural and phenol in the presence of an acid catalyst results in a different type of resin. By altering the ratio of phenol to furfural from 10 : 1 to 5 : 1 the final product may be changed from a resin which is fusible and soluble to one which is infusible and insoluble. Further types may be obtained by the action of caustic alkalies on furfural or by condensation with phenols.

The full industrial value of these resins has not yet been investigated. The insoluble infusible materials can be moulded with ease, and if certain fillers such as wood flour are incorporated with them, the products possess high tensile strength. The products of the phenol-furfural condensation, particularly, when treated in this manner, are efficient electrical insulators, and are used in the construction of electrical apparatus. Gramophone records and printing plate matrix have also been made with this material. These resins are soluble in cellulose acetate and it is therefore suggested that they may be valuable in the preparation of dope and insulating varnishes. The resin produced by the action of alkalies on furfural is soluble in organic solvents such as alcohol, benzine, acetone and furfural. The great penetrative power of furfural and its pronounced fungicidal properties suggest that a solution of the resin in this solvent would be valuable as a wood preservative.

A recent process enables pure cellulose to be produced from wood by the action of phenol. The furfural obtained from the liberated lignin and pentosan combines with the phenol to form a resinous material which can be used in place of natural asphalts and pitches or dissolved in solvents to form a varnish.

The value of by-product furfural depends largely on the industrial applications of these resinous products. Until these substances are more widely used, only those waste vegetable materials which give high yields of furfural at minimum cost can be utilized profitably.—(*Ind. Chem.* Vol. VI, p. 479.)

* * *

Plantation Rubber.

Important statistics regarding the production of rubber were given in a paper read on 13th January, by Dr. G. Rae, at Birmingham, to the Midland Section of the Institution of the Rubber Industry. The total area under plantation rubber at the end of 1929, he said, was between 6,600,000 acres and 7,200,000 acres, of which the area under native rubber in the Dutch East Indies was variously estimated at between 1,100,000 acres and 1,700,000. About 3,360,000 acres were in estates owned by Europeans and Americans; 510,000 acres in Asiatic-owned estates of more than 100 acres, and 1,630,000 acres in native holdings of less than 100 acres. The total exports of rubber from producing countries were 94,000 tons in 1910; 354,000 tons in 1920; 518,000 tons in 1925, and 861,000 tons in 1929. The output for 1930 was 820,000 tons. Of the output in 1929, British producers were responsible for 36 per cent. Dutch and other European producers 10.2 per cent. and American producers 2.6 per cent. The absorption of rubber by manufacturers (that is, the quantities of rubber they turned into rubber goods) was 85,000 tons in 1910; 310,000 tons in 1920, 560,000 tons in 1925; 790,000 tons in 1929. but would be approximately only 705,000 tons in 1930.—(*Nature*, Vol. 127, No. 3195.)

* * *

Paper from Rice Straw.

A satisfactory paper has recently been made with rice straw as the chief raw material. Hitherto, the high ash content of rice straw has precluded its use in paper manufacture. The normal ash content for good raw material for paper is about 3.7 per cent. whereas rice straw may contain as much as 14.5 per cent. of ash. The paper obtained by normal methods of treatment has consequently been of inferior quality. Experiments have recently been conducted in Italy which have shown that a new process which utilises the fact that the silica in rice straw is in organic rather than inorganic combination, can be used to produce a good quality paper from rice straw on a commercial scale. It is anticipated that the new process will exert an important influence on the rice growing industries of Egypt and India.—(*Chem. and Ind.* p. 876, 1930.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.):

	Foreign.	*Preferential.*
	s. d.	*s. d.*
22nd January ...	6 2¼	9 4½
29th January ...	6 1½	9 4½
5th February ...	6 10½	9 7½
12th February ...	6 1½	9 9
19th February ...	6 2¼	9 10½
26th February ...	6 2¼	9 11¼
5th March ...	5 11¼	9 8¼
12th March	6 0	9 9

Since our last Report the market has remained quiet and there has been little change in values. According to *C. Czarnikow Ltd.*, markets are in a waiting attitude pending the final ratification of the Chadbourne Scheme and whilst a certain amount of scepticism is in evidence in certain quarters as to the ultimate effect of the scheme on the future trend of prices, the view most generally held is that a strict adherence to the plan must in the long run lead to a more balanced statistical position, with a consequent return to more remunerative levels. The Cuban President signed a Decree on 31st January limiting the current Cuban Crop to 3,122,000 tons.

* * *

COCOA.—The effect of the collapse of the attempt of the African farmers to withhold their cocoa from the market seems to have been fully discounted in the recent low prices. Supplies are being well taken up and warehouse stocks continue to decline. It appears likely that the current crop from Accra will be well absorbed and indications point to a crop not exceeding 200,000 tons. We believe that were manufacturers to carry normal supplies considerable improvement will be shown in prices.—(*By courtesy of the Cocoa Planters' Association, Trinidad.*)

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

			d.
22nd January	..	..	$4\frac{1}{8}$
29th January	..	..	4
5th February	..	..	$3\frac{3}{16}$
11th February	..	..	4
18th February	..	..	$3\frac{13}{16}$
25th February	..	..	$3\frac{3}{4}$
4th March	..	..	$3\frac{3}{16}$
11th March	..	..	4

Since our last Report the Rubber market has been generally dull and prices have shown an inclination to sag. According to *Messrs. Symington and Sinclair*, the present fall in price may prove in the long run to be to the advantage of the industry as a whole if it brings home to the producers the necessity for drastic curtailment of output. * * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:

	American Mid.	*Egyptian F. G. F. Sakel.*	*Sea Island.*		
			Good.	*Extra fine.*	*Prices paid this Week.*
23rd Jan.	5·63	8·55	20·00	35·00	—
30th Jan.	5·63	8.85	19·00	34·00	19·00
6th Feb.	5·72	9·00	19·00	34·00	—
13th Feb.	5·85	9·35	19·00	34·00	—
20th Feb.	6·04	—	19·00	34·00	—
27th Feb.	6·18	—	20·00	34·00	—
6th Mar. .... (local)	6·09	—	18·00	34·00	—

Since the last Report there has been more activity in all markets, all varieties showing a considerable advance. The strength of the stock and grain markets has affected sentiment, but, on the whole, it is felt that the rise in prices has weakened the technical position and a reaction is expected. Acreage prospects continue to show a declining estimate in reduction. Sea Island has been neglected.

* * *

COFFEE.—Prices have shown little fluctuation. Central American has sold at 95*s.* per cwt., Kenya up to 147*s.*, Costa Rica 97*s.* 6*d.*, and 141*s.*

* * *

TEA.—According to the *Times Trade and Engineering Supplement* the serious fall in the average prices of tea which has occurred recently is attributed to the presence of very large stocks of the commodity and to consigners sending quotas of very inferior tea out of proportion to usual expectations. Tea stocks in millions of lb. are 274 as against 267 in 1930. Latest averages are: Ceylon, 15.07*d.*; Indian 11.91*d.*; Java, 8.23*d.*

* * *

COPRA.—West Indian f. m. s. is a little lower at £15 7*s.* 6*d.*, No. 2 contract terms c. i. f. London or Rotterdam.—(*West India Committee Circular*, 19th February.)

* * *

BANANAS.—Bananas generally have continued in quiet demand. Elders and Fyffes' prices of Jamaicas are unchanged at £18 5*s.* per ton delivered (London), and £18 delivered nearest railway station, but the Jamaica Producers are £1 lower at £18 delivered. Brazilians are in slightly improved request and unchanged at £18 per ton delivered nearest railway station.—(*West India Committee Circular*, 19th February.)